SURVEY REPORT
YOUGHIOGHENY RIVER WATERSHED

PROGRAM FOR
RUNOFF AND WATERFLOW RETARDATION
AND SOIL EROSION PREVENTION

U. S. DEPARTMENT OF AGRICULTURE

MARCH, 1951

UNITED STATES DEPARTMENT OF AGRICULTURE

PRODUCTION AND MARKETING ADMINISTRATION

FIELD SERVICE BRANCH

[illegible]

[illegible]

To: Mr. [illegible], State Conservationist

From: Clyde A. [illegible], Chairman, State P.M.A. Committee 68453

Subject: Youghiogheny River Watershed Report

We have read with interest the report on the Youghiogheny River Watershed and I appreciate your thoughtfulness in mailing me a copy.

Those responsible for the work have done an excellent job of pointing out the causes and making suggestions for correcting the conditions which are causing such a terrific loss each year. I have only two suggestions to make. (1) That someone check the figures on Exhibit A page 5 which states that at present 53% of the farm woodlots containing 19% of the total forest area are being grazed. If these figures are correct, I feel that all agencies concerned have a big job to do in getting farmers to realize the damage that is being done to this vast woodland area.

We are going to check our figures to determine the amount of this woodland area that might be reported as pasture and as such we would be making an appropriation to those counties for pasture improvement when in reality we would be encouraging the building of fences to keep livestock out of the woods.

The other comment that I have to make is the paragraph "Losses in Fish and Wildlife" on Page 8-12 It would seem to me that if we can justify spending $11,000,000 and I believe we can, based on $[illegible],000,000 annual saving from benefits derived from this expenditure of public money, that this project should include plans to remove the pollution of waters caused by industries and coal mining wastes from the area. If this phase of the project cannot be handled by the federal government, I believe it would be time well spent to explore the possibilities of having the state coordinate a clean stream program for the area at the same time that the other corrective measures are being put into effect.

Clyde A. Zehner

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UNITED STATES
DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Upper Darby, Pa.
April 4, 1951

Mr. Clyde A. Zehner
Chairman, State PMA Committee
Production & Marketing Administration
928 N. Third Street
Harrisburg, Pennsylvania

Dear Mr. Zehner:

I wish to thank you for your comments on the preliminary draft of the Youghiogheny River Watershed Report and Appendixes which you presented in your letter of February 26, 1951, addressed to Ivan McKeever, State Conservationist at Harrisburg, Pennsylvania.

The statement on page A-5 of the appendix, which states that 53 percent of the farm woodland is being grazed, has been rechecked and found to be correct. I agree with you completely that there is a tremendous job to be done by all agencies, both state and federal, in correcting this condition.

Your comment that the report should have included recommendations for keeping industrial and coal mining wastes out of the streams is interesting because that same comment was made by others. The problem of polluted streams is certainly a pertinent one today. However, the scope of this Departmental report is limited to recommendations for water retardation and soil-erosion prevention; therefore, it was not possible to recommend a definite program for the correction of this problem.

Very truly yours,

Austin L. Patrick

Austin L. Patrick
Regional Director

cc: Ivan McKeever

UNITED STATES DEPARTMENT OF AGRICULTURE
Production and Marketing Administration
College Park, Maryland

March 14, 1951

68709

Mr. Edward M. Davis
State Conservationist
Soil Conservation Service
U. S. Department of Agriculture
College Park, Maryland

Dear Mr. Davis:

Your letter enclosing a report of a survey of the Youghiogheny River was duly received. We have carefully examined this report and to the best of our knowledge, it seems to be very carefully prepared. Other than this we have no other comments to make.

Very truly yours,

Jos. H. Blandford, Chairman
Maryland PMA State Committee

JHB/sl

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UNITED STATES DEPARTMENT OF AGRICULTURE
Production and Marketing Administration

Morgantown, West Virginia
March 15, 1951

68817

Mr. L. L. Lough, State Conservationist
Soil Conservation Service
Morgantown, West Virginia

Dear Mr. Lough:

The State PMA Committee and State Office Representative assigned to Flood Control work have reviewed the Youghiogheny River Watershed Report and Appendixes and agree with the several recommendations made therein. We commend those who have prepared this material for their thorough method of compiling data.

For your information, Mr. John R. Runner has been designated as the State Office Representative who will work on River Basin and Flood Control work.

In the event no State PMA Committeeman is available, Mr. Runner is well qualified to discuss such matters.

Yours very truly,

J. Ward Wood.

J. Ward Wood, Chairman
West Virginia PMA Committee

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UNITED STATES DEPARTMENT OF AGRICULTURE

YOUGHIOGHENY RIVER WATERSHED

Pennsylvania, Maryland, and West Virginia

3a

Program for Runoff and Waterflow Retardation and Soil-Erosion Prevention

Pursuant to the Act Approved June 22, 1936 (49 Stat. 1570) as Amended and Supplemented by the Act Approved August 28, 1937 (50 Stat. 876)

C O N T E N T S

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
H. H. BENNETT, CHIEF

YOUGHIOGHENY RIVER WATERSHED
PENNSYLVANIA · MARYLAND · WEST VIRGINIA

NORTHEAST REGION 1
AUSTIN L. PATRICK
REGIONAL DIRECTOR

Fig. ~-1

Prepared by Regional Cartographic Division Upper Darby, Pa.

September 1..

INTRODUCTION

Authority - This report is submitted under the provisions of the Act approved June 22, 1936 (49 Stat. 1570), as amended and supplemented by the Act approved August 28, 1937 (50 Stat. 876).

Purpose and Scope of Report - The purpose of this report is to outline a program of runoff and waterflow retardation and soil erosion prevention for the Youghiogheny River Watershed in Pennsylvania, Maryland, and West Virginia; and to present recommendations for installing and maintaining the program, together with an analysis of the costs and benefits.

The Youghiogheny River is a tributary of the Monongahela River and has a watershed area of 1,762 square miles, of which 72 percent is located in Pennsylvania, 24 percent in Maryland, and 4 percent in West Virginia.

RECOMMENDATIONS

It is recommended that a program of runoff and waterflow retardation and soil-erosion prevention be installed in the Youghiogheny River Watershed in Pennsylvania, Maryland and West Virginia during a 20-year period at an estimated cost of $4,350,000 to the Federal Government, and $4,602,000 or its equivalent 1/ to local interests, making an estimated total cost of $8,952,000 for the installation of the recommended program.

1/ Labor, materials, equipment, land, easements, rights-of-way, and other contributions in lieu of cash payments.

The program will be operated and maintained at an estimated annual cost of $22,500 to the Federal Government and $743,600 or its equivalent to local interests, making an estimated total annual cost of $766,100.

The recommended program, consisting only of measures and practices that contribute to substantial and measurable reductions in floodwater and sediment damage, includes certain adjustments in land use in accordance with the needs and capabilities of the land and the following practices and measures: contour strip cropping, cover cropping, diversions and terraces, outlets and waterways, establishing perennial hay, pasture management, contour furrowing, streambank erosion control, erosion control structures, improved forest management, tree and shrub planting, public land acquisition, stream channel improvement and water retarding structures.

Technical services will be made available for planning and applying the necessary land use adjustments, for planning and applying conservation measures on the watershed and for integrating the measures included in the recommended program. Educational assistance, to facilitate the establishment of the measures and practices, will be provided as part of the recommended program.

The Secretary of Agriculture may make such modifications or substitutions of the measures described herein as may be deemed advisable due to changed physical or economic conditions or improved techniques whenever he determines that such action will be in furtherance of the objectives of the recommended program.

It is estimated that the recommended program will yield an average annual benefit of $2,515,900. Attainment of this estimated benefit depends on the installation and proper maintenance of all phases of the recommended program.

Based on prices and costs expected to prevail under intermediate employment levels during the period 1955 to 1965, the ratio of the average annual benefit to the average annual cost is 1.87 to 1.

The recommended measures will be installed and maintained under cooperative arrangements with state and local governments, soil conservation districts, or other agencies acceptable to the Secretary of Agriculture.

The program herein recommended includes the intensification, acceleration, and adaptation of certain activities under current programs of the Department of Agriculture, and additional measures not now regularly carried out in such programs, all of which are necessary to complete a balanced runoff and waterflow retardation and erosion control program for the watershed. It is recommended that the Secretary of Agriculture be authorized to carry out this program. The extent to which the work recommended in this program is to be carried out under authority of the Flood Control Act as requested herein or under other authorities will be considered by the Secretary in requesting appropriations for the conduct of the recommended program. Although the current activities of the Department primarily related to the Flood Control Act are not included in the program herein specifically recommended, this program is based

on the continuation of such current activities at least at their present level. The extent to which the measures in the recommended program may be carried out by an increase in the current programs of the Department will be taken into account in requests for the appropriation of funds to carry out the recommended program.

The Secretary of Agriculture may construct such buildings and other improvements as are needed to carry out the measures included in the recommended program.

The authority of the Secretary of Agriculture to prosecute the recommended program shall be supplemental to all other authority vested in him, and nothing in this report shall be construed to limit the exercise of powers heretofore or hereafter conferred on him by law to carry out any of the measures described herein or any other measures that are similar or related to the measures described herein.

DESCRIPTION OF THE WATERSHED

The Youghiogheny River, a tributary of the Monongahela River, flows in a general northwesterly direction and joins that River at McKeesport, Pennsylvania, about fifteen miles upstream from Pittsburgh, Pennsylvania. Its watershed lies within the Allegheny Mountains and Plateau Sections of the Appalachian Mountain System in southwestern Pennsylvania, western Maryland, and northern West Virginia. The mountain section, comprising approximately 75 percent of the watershed, is characterized by parallel, high mountain ridges running in a northeast-southwest direction. The plateau section is a dissected area characterized by rounded hills and steep-sided

stream valleys. The inter-mountain valleys are deeply dissected, with topography varying from rolling to hilly.

The average annual precipitation, based on U. S. Weather Bureau records of 40 to 75 years' duration, ranges from 36 inches at the mouth of the river to 53 inches in the headwaters area in Maryland and West Virginia.

Approximately 588,700 acres or 52 percent of the watershed is in forest, 280,300 acres or 25 percent in hay and pasture, 139,400 acres or 12 percent in row and grain crops, and 119,300 acres or 11 percent in urban, roads, water and miscellaneous uses.

Forest lands are in poor condition as a result of past treatment. Clear cutting, livestock grazing, and forest fires have affected large areas. These areas are understocked with immature stands containing many undesirable species.

Improper management of a large percentage of the farm openland area has resulted in excessive erosion. Tillage practices in current use on most of the cropland permit rapid runoff and soil loss.

Coal mining and related activities are important enterprises in the watershed. Injuries to the land throughout the mining section are noticeable as large areas of waste over-burden from strip mining, fields pock-marked by mine cave-ins, streams discolored and polluted by mine seepage, and culm dumps encroaching on streams and villages.

The population of the watershed in 1940 was approximately 291,000 of which about 14 percent was rural-farm. McKeesport, located at the mouth of the river, is the largest city. Most of the

boroughs and cities are located in the plateau section of the lower part of the watershed.

There are approximately 7,400 farms in the watershed, which include about 655,000 acres, or 58 percent of the watershed. The major farm products are livestock, hay, grain, potatoes, canning peas, maple syrup, and miscellaneous forest products. Most of the non-farm land is wooded and located in the mountainous areas.

FLOOD PROBLEMS

Moderate to heavy rains of several days' duration covering large areas and occurring in the winter or early spring, sometimes associated with melting snow, produce the most severe floods. Among the recorded floods of this type were those of March 1936, March 1924, March 1912, March 1907, and February 1897. Of 49 recorded floods at McKeesport, Pennsylvania, from 1858 to 1945 inclusive, 80 percent occurred during the months of December, January, February, and March.

The March 1936 flood, the largest recorded, caused damages within the watershed equivalent to approximately $2,754,000 based on 1949 prices. Discharge from the Youghiogheny River also contributed to the damage at points below its confluence with the Monongahela River.

Total damage in terms of 1949 prices, caused by the 1936 flood at downstream points, would be $11,577,000 at McKeesport, $219,394,000 at Pittsburgh, Pennsylvania, and $57,887,000 at Wheeling, West Virginia. The major damages were industrial, commercial and residential.

Severe localized floods occur frequently throughout the watershed, but they are of relatively infrequent occurrence in any one small drainage area. These floods are usually caused by intense local summer storms, and do not necessarily create flood flows on the main streams. Two floods illustrative of this type caused damages of approximately $167,000 in a 21 square mile drainage basin, and $15,000 in a 17 square mile drainage basin.

On some of the small tributaries, losses are an annual occurrence. These floods most commonly occur in the spring and early summer, and the losses sustained are mainly to highways, and growing crops and pasture.

Serious flood problems exist at several upstream urban communities. An example is the flood problem at Oakland, Maryland, where the average annual damage amounts to several thousands of dollars.

Damages caused by sedimentation occur mainly as increased cost of maintenance on highways, navigable channels and decreased agricultural production in the bottomland of some of the small tributaries. Highway damages are most frequently the result of deposition in road culverts and on the road surface. Cultivated farm land is the major source of sediment, and the greatest damage is inflicted when storms occur during the early growing season when the fields do not have sufficient protective vegetative cover. Deposition of sediment in low gradient stream channels and on adjacent bottomland is one of the factors contributing to increased frequency of flooding, and intensification of land drainage problems. This condition has decreased crop production in some of the small drainage basins.

Other damages caused by floods, while not evaluated in monetary terms in this report, include loss of life, illness, insecurity of property and income, disruption of public services, disturbance of the general economic and social activity of the area, and destruction of fish and game.

Average annual damages within the watershed and at points affected by the discharge of the Youghiogheny River are shown in table 1. These damages do not include those which will be prevented by current flood control projects of the Department of the Army, Corps of Engineers.

Table 1. Estimated Average Annual Recurrent Monetary Damage
Youghiogheny River Watershed
(1949 Prices)

Type of Damage	Average Annual Damage	
	(dollars)	
Damage Due to Inundation		
Within Watershed	140,600	
Below Watershed	1,678,000	
Subtotal		1,818,600
Damage Due to Sediment		54,050
Damage Due to Erosion		607,900
TOTAL AVERAGE ANNUAL DAMAGE		2,480,550

ACTIVITIES RELATED TO FLOOD CONTROL

The Department of Agriculture is actively cooperating with state and local agencies in carrying out programs for the conservation of soil, water, and timber resources in the watershed.

The Forest Service cooperates with state forestry agencies in providing protection from forest fire, in making tree seedlings available for reforestation, and in providing limited technical services to assist owners in proper management of forest lands. In recent years the state fire protection organizations have provided protection that is considered adequate for flood control purposes.

The Production and Marketing Administration, with its Agricultural Conservation Program of direct aids, offers financial assistance to farmers for carrying out soil and water conservation practices.

The Department also cooperates with State Extension Services and Experiment Stations in educational and research work in the conservation of soil and water resources.

The Soil Conservation Service is currently assisting soil conservation districts in the application of soil and water conservation practices and measures on farm lands.

Although the primary purpose of these conservation programs in this watershed has been the maintenance of soil resources and improvement of crop and timber yields, they have produced some flood control benefits.

The present annual Federal cost of those portions of the

Department's "going" programs which produce flood control and associated benefits is approximately $86,000.

Seventeen flood control reservoirs proposed by the Department of the Army, Corps of Engineers, for construction in the Upper Ohio - Beaver Drainage Basin have been authorized in the Flood Control Acts of 1936, 1938, 1941, and 1944. The Tygart River Reservoir was authorized by the Public Works Administration in 1934 and adopted by the Rivers and Harbors Act Approved August 30, 1935. Of the eight reservoirs which have been constructed and the two under construction one is located in the Youghiogheny Watershed. The Youghiogheny River Reservoir, now in operation, was constructed under the general authorization for the Ohio River Basin contained in the Flood Control Act Approved June 28, 1938 (52 Stat. 1215). The program herein recommended will supplement that of the Department of the Army, Corps of Engineers, in alleviating the flood situation on the Youghiogheny River and in downstream damage districts such as McKeesport and Pittsburgh, Pennsylvania, and Wheeling, West Virginia. The benefits of the program herein recommended do not include the benefits to be provided by the eight reservoirs constructed and the two reservoirs in the process of construction.

Soil conservation districts, organized under state laws, include that portion of the watershed in Preston County, West Virginia, Garrett County, Maryland, and Allegheny and Westmoreland Counties in Pennsylvania, or approximately 48 percent of the watershed. A program of soil and water conservation and land management on farm lands is being developed by these districts.

About 11 percent of the forest land in the form of public

forests, parks, and game lands is administered by state or other public agencies. In general present management is satisfactory for flood control purposes and these areas are protected from fire and grazing.

RECOMMENDED PROGRAM

The recommended program of runoff and waterflow retardation and soil-erosion prevention includes certain land use adjustments in accordance with the needs and capabilities of the land and the following practices and measures.

Contour Strip Cropping

The practice of growing hay or other close growing and soil conserving crops in contour strips, alternating with clean tilled or soil depleting crops, will be applied on approximately 129,000 acres of cropland. Contour tillage operations in conjunction with contour strip cropping will provide appreciable surface detention storage for runoff. Such a system will, in addition, keep at least half the sloping cropland in erosion resisting crops at all times, lessen the amount and velocity of runoff and the concentration of water in gullies or channels, thereby reducing the losses of soil by erosion.

Cover Cropping

The practice of growing temporary crops to provide vegetative cover on land following the harvesting of clean tilled crops until the next regular crop is planted will be applied on approximately 19,100 acres of cropland. A satisfactory vegetative cover will lessen the impact of rain drops on the soil, thus reducing

erosion and maintaining the soil in condition to readily absorb water. The organic matter added to the soil by cover cropping will increase its water holding capacity.

Diversions and Terraces

Approximately 960 miles of diversions and terraces will be installed to provide for intercepting surface runoff from sloping land and carry it in properly designed and constructed channels across the slopes to an outlet or waterway. Terraces will be installed on the more moderately sloping land with short rotations. Diversions will be installed on the steeper slopes and in conjunction with less intensive rotations. The installation of these measures will furnish protection from damaging runoff to the lands lying immediately below and will significantly reduce erosion and sediment production.

Outlets and Waterways

Adequate systems for the disposal of runoff water are a necessary part of the program to reduce floodwater and sediment damage. Approximately 190 acres of outlets and waterways will be established to provide for the safe disposal of runoff from terrace and diversion systems. This will result in reduced gully erosion and sediment production. The outlets and waterways will be vegetated and will include broad meadow strips and constructed channels. Supporting structures, required as a part of the disposal system, are included with the recommended erosion control structures.

Establishing Perennial Hay

Approximately 28,900 acres of perennial grasses and legumes will be established to protect land not suitable for row crops and

to protect such measures as diversions, and outlets and waterways. This measure through increasing the infiltration rate, will reduce runoff and flood damage and, by protecting other measures, will reduce gully erosion and the resulting sedimentation.

Pasture Management

Pasture management consisting of mowing to remove weeds and mature grasses, the scattering of droppings, and the control of grazing intensity will be applied on approximately 96,500 acres of pasture so that the improved vegetative cover will prevent erosion and increase infiltration. Fences will be used to facilitate the control of grazing intensity. Brush or other obstructions to mowing will be removed where feasible.

Contour Furrows

Level furrows or small level terraces will be installed on approximately 48,700 acres of pasture land. The furrows will be spaced and constructed so that approximately one-half inch of runoff will be held in detention storage. In addition to reducing runoff, the installation of this measure will control erosion on sediment source areas.

Streambank Erosion Control

Approximately 4.0 miles of eroding streambanks along minor tributaries will be controlled by the use of riprap and shrub plantings. Livestock will be excluded by either wire or multiflora rose fence. The establishment of this measure will reduce the loss of fertile bottomlands and the quantity of sediment getting into the streams.

Erosion Control Structures

Approximately 970 erosion control structures including small check dams, gully structures, and culverts will be installed as part of the water disposal system or for gully stabilization. Concentration of runoff requires special erosion control structures to protect channels or natural drainageways from gullying and to furnish protection to railroad and highway ditches. New and larger culverts will be necessary to discharge runoff safely under railroad and highway fills. The establishment of this measure will reduce the rate of gully erosion in existing drainageways and permit the installation of adequate water disposal systems which will materially reduce sheet and gully erosion on the fields protected.

Improved Forest Management

This measure provides for the intensification of management on all forest lands for the purpose of improving their hydrologic conditions. In the main, this improvement will consist of the development of a better forest floor. Under such conditions, infiltration rates will be greater, detention storage capacity will be increased, and the area of impermeably frozen soil will be reduced during the winter and spring. This will result in reducing the surface runoff and erosion from forested areas.

Coincidental with hydrologic improvement, increased growth and stocking of forest land will ultimately provide higher and more sustained income from those lands. Such returns will make it profitable for owners to participate in the program and more than justify the costs involved.

Improved forest management will be accomplished through an expanded program of technical services. These services will afford help in planning and applying forest land measures, including the preparation of management plans for 212,800 acres in private holdings and 71,300 acres to be acquired in public ownership. The plans will outline the steps necessary to operate forest land efficiently and economically while integrating watershed protection and timber production objectives. Technical service and advice on timber marking will be provided to minimize clear cutting and destructive logging practices in harvest cuttings and to improve timber stands. These steps are necessary to develop and maintain the healthy soil conditions and vigorous growth needed to realize the objectives of the program. Additional technical service will be required on 63,100 acres of forest land on shallow soil areas where cultural operations are needed to improve stand composition. Here the aim will be the development of thrifty, mixed stands of species whose litter is highly favorable for humus production, thereby contributing maximum quantities of organic matter to the soil as a means of increasing its moisture storage capacity.

Technical advice will be furnished the owners of 337,300 acres of forest on logging methods which cause the least disturbance to forest soil and cover, including the proper installation and location of logging roads and skid trails. Existing roads and trails are sources of aggravated runoff and sedimentation as a result of poor location and inadequate drainage facilities. Correction of the unsatisfactory conditions resulting from past operations

and the prevention of their recurrence in future operations is necessary if other forest management practices are to be fully effective. This will be accomplished by the installation of water spreading devices, small check dams, gully structures and culverts.

Livestock will be excluded from 56,800 acres of present farm forest land and from 14,000 acres of land to be converted from openland to forest as a part of forest land management. Grazing reduces the organic matter and compacts forest soils, thereby reducing seriously their infiltration and water holding capacity. Grazing control must be instituted as an essential part of proper forest management, if the previously mentioned installations and practices are to be effective.

To assure the cooperation of local owners in the installation and maintenance of good forest management practices, advice and assistance will be given on the utilization and marketing of forest products.

Tree and Shrub Planting

The total forest area will increase from 593,000 acres to 602,500 acres by the conversion of 15,600 acres of openland to forest by planting and the clearing of 6,100 acres of present forest land for pasture. Trees will be planted to establish a soil improvement and watershed protective cover on approximately 15,600 acres of openland which will not restock naturally within a reasonable length of time. Early establishment of a forest cover on these lands will reduce soil movement, increase infiltration rates, and enlarge soil moisture storage capacity. These trees will be planted on approximately 14,000 acres of private land and on about 1,600 acres of

land to be acquired by public agencies.

Shrubs will be planted on about 5,800 acres of field borders. Installation of this practice will provide good land cover in the partially shaded areas adjacent to forests and improve infiltration and soil moisture storage capacity, thereby reducing runoff and erosion.

Public Land Acquisition

Public acquisition is recommended for approximately 83,000 acres of damaged headwaters land. These areas, normally well forested, have so been abused that they constitute critical floodwater sources and need major rehabilitation to restore the watershed cover for effective runoff and sediment control. Because of low productivity and the low returns to be derived from this land for many years, many landowners are not able to manage their land for either watershed protection or timber production. Public acquisition is an essential first step in insuring the establishment of necessary rehabilitational measures and providing continuity of management.

The objectives of the program can be met by acquisition by state or local governments. The land will be acquired through voluntary sales by owners in accordance with existing state policy.

Stream Channel Improvement

Approximately 32 miles of tributary stream channels will be improved to reduce the damages resulting from inundation of

valuable bottomland, provide outlets for drainage works and furnish flood protection for high-value improvements, such as highways, railroads, bridges, and farm buildings. The capacity of stream channels will be increased by the removal of debris and sediment deposits, realignment, and bank sloping.

Water Retarding Structures

Seven upstream floodwater retarding structures with provisions for the temporary storage of runoff will be constructed to reduce inundation damage. Drainage areas above the structures will average less than 1 square mile. These structures will be earth fill dams through which a small, low elevation outlet conduit uncontrolled by gates or valves will be constructed to draw down the temporary storage. A spillway adapted to site conditions and meeting required design criteria will be used to provide an outlet for flood flow in excess of the storage capacity provided by the structure.

The quantities of measures included in the recommended program are based on total watershed needs less the estimated accomplishments under "going" programs over a 20-year period. Minor reductions in the acreages of clean tilled and small grain crops and large increases in the acreage of managed pasture, perennial hay, and forest land will result from the installation of recommended program.

Educational Assistance

Landowners and operators and others in the watershed will be furnished educational assistance relative to the need for the

recommended program and its purposes and objectives. Information will be supplied as to the manner in which landowners and operators now obtain services and assistance that are available through the various governmental agencies, and how they can and should, by their own efforts, contribute successfully and most economically to the accomplishment of the overall objectives. Intensified educational efforts will be directed to familiarizing farmers with the specific practices and measures essential to runoff and water-flow retardation and soil-erosion prevention, how to install those measures not requiring the detailed assistance of a specialized technician, how to maintain them, and how to integrate them into the soundest farming system to produce the greatest benefit over a long period of time.

The Department is committed to a watershed and subwatershed approach in carrying out the recommended program. It is essential that educational assistance provided under this program be directed toward furthering the specific objectives of floodwater and sediment damage reduction and that it be fitted as to method and synchronization into subwatershed operations activities.

Technical Services

Technical services will be provided for (1) planning and applying improved forest management practices for watershed protection, (2) planning and applying land use adjustments, (3) planning and applying conservation measures on the farm, and (4) integrating the installation of individual measures into a proper combination to achieve the most effective program of runoff and waterflow retardation and soil erosion prevention. These services

are required to assist the people in the watershed in installing the recommended measures on their land and in adopting the recommended practices for their farm and woodland operations.

P.m.d.

COST OF RECOMMENDED PROGRAM

The estimated cost of installing the recommended program in the Youghiogheny River Watershed is shown in table 2.

The Federal Government will bear approximately 48.6 percent of the total installation cost, state and local governments approximately 17.6 percent, and private interests approximately 33.8 percent.

Table 2. Estimated Cost of Installing the Recommended Program
Youghiogheny River Watershed
(1949 Prices)

Measure	Unit	Quantity	Total Cost
			(dollars)
1. Contour Strip Cropping	Acres	129,000	420,000
2. Cover Cropping	"	19,100	92,000
3. Diversions and Terraces	Miles	960	395,000
4. Outlets and Waterways	Acres	190	81,000
5. Establishing Perennial Hay	"	28,900	1,350,000
6. Pasture Management	"	96,500	789,000
7. Contour Furrows	"	48,700	731,000
8. Streambank Erosion Control	Miles	4	55,000
9. Erosion Control Structures	No.	970	593,000
10. Improved Forest Management	Acres	337,300	2,142,000 1/
11. Tree and Shrub Planting	"	21,400	509,000
12. Land Acquisition	"	83,000	813,000
13. Stream Channel Improvement	Miles	30	812,000
14. Water Retarding Structures	No.	7	170,000
TOTAL			8,952,000

1/ Includes necessary maintenance during installation period.

The costs of administration of direct aids, technical services, and educational assistance are included in the above costs. The estimated costs for technical services and educational assistance amount to approximately 18.5 percent and 2.0 percent respectively of the installation cost of the recommended program.

Of these amounts, non-federal public agencies will bear one-half the cost of technical services on privately owned forest land and one-half the cost of educational assistance. The estimate includes about 2.6 percent of the total cost for the administration of direct aids.

The estimated average annual cost of operating and maintaining the recommended program is $766,100. The Federal Government will bear approximately 5.8 percent of this annual maintenance cost to provide technical services necessary to assure proper use and conservation and management of lands. State and local governments will bear approximately 8.4 percent of this cost, and private interests will bear the remaining 85.8 percent.

BENEFIT FROM RECOMMENDED PROGRAM

The estimated average annual monetary benefit resulting from the recommended program when it attains maximum effectiveness is shown in table 3.

In addition to the benefits listed in table 3, there are many unevaluated benefits, such as saving of life and alleviating mental distress, improving community organizations and facilities, maintaining and increasing the tax base, improving recreational opportunities, and increasing fish and game production.

Table 3. Estimated Average Annual Monetary Benefit
from the Recommended Program
Youghiogheny River Watershed
(1949 Prices)

Type of Benefit	Average Annual Benefit	
	(dollars)	
Reduction in Damage Due to Inundation:		
Within Watershed	28,100	
Below Watershed	59,800	
Subtotal		87,900
Reduction in Damage Due to Sediment		29,800
Reduction in Damage Due to Erosion		364,700
Land Enhancement		64,200
Other Benefits: 1/		
Increased Crop Production	622,700	
Increased Pasture Production	311,700	
Increased Forest Land Production	578,800	
Saving in Crop Production Costs	456,100	
Subtotal		1,969,300
TOTAL		2,515,900

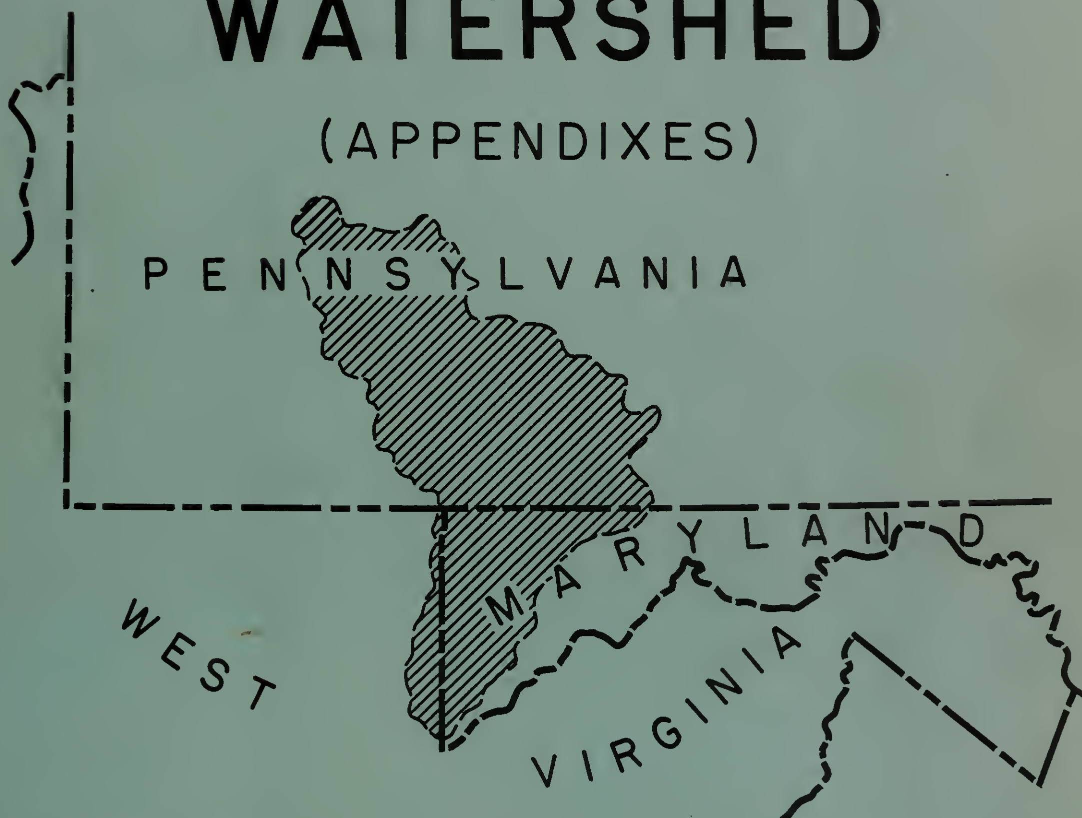
1/ Benefits which accrue to the owners and operators of the land on which the recommended program is installed.

COMPARISON OF BENEFIT AND COST

Based on prices and costs expected to prevail under intermediate employment levels during the period 1955 to 1965, the ratio of the average annual benefit to the average annual cost of the recommended program is 1.87 to 1.

SURVEY REPORT YOUGHIOGHENY RIVER WATERSHED

(APPENDIXES)



PROGRAM FOR
RUNOFF AND WATERFLOW RETARDATION
AND SOIL EROSION PREVENTION

U. S. DEPARTMENT OF AGRICULTURE

MARCH, 1951

NOTE

Certain discrepancies exist between the report and these appendixes in connection with the acreage to be treated by woodland measures, the cost of such measures, the benefits to be derived from them, and the benefit-cost ratio of the recommended program. Details concerning these discrepancies are shown on pages G-11 and G-12.

UNITED STATES DEPARTMENT OF AGRICULTURE

APPENDIXES
SURVEY REPORT

YOUGHIOGHENY RIVER WATERSHED

Pennsylvania, Maryland, and West Virginia

Program for Runoff and Waterflow Retardation and
Soil-Erosion Prevention

Pursuant to The Act Approved June 22, 1936 (49 Stat. 1570)
as Amended and Supplemented by The Act Approved
August 28, 1937, (50 Stat. 876)

C O N T E N T S

Appendixes

APPENDIX A

DESCRIPTION OF THE WATERSHED

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APPENDIX A. DESCRIPTION OF THE WATERSHED

Location and Size

The Youghiogheny River, a part of the Upper Ohio River system, rises in western Maryland and northern West Virginia and flows in a north-westerly direction through southwestern Pennsylvania to its junction with the Monongahela River at McKeesport, Pennsylvania. McKeesport is located 15 miles above Pittsburgh, Pennsylvania, where the Ohio River is formed by union of the Monongahela and Allegheny Rivers. Some 24 percent of the Youghiogheny River Watershed is in Maryland, 72 percent in Pennsylvania, and 4 percent is in West Virginia. The drainage pattern with the larger tributaries is shown in Figure A-1. The entire watershed is in the Appalachian Plateau Physiographic Province.

An area of 1,762 square miles is drained by the Youghiogheny River. This represents 9 percent of the total drainage area of the Ohio River at Pittsburgh. The main stream is 130 miles long. Principal tributaries of the Youghiogheny River are Casselman River with a drainage area of 576 square miles which includes the 126 square mile drainage area of Laurel Hill Creek, and Indian, Jacobs and Sewickley Creeks with drainage areas, respectively, of 126, 95, and 165 square miles.

Topography, Geology and Soils

The upper 75 percent of the watershed is in the Allegheny Mountain section of the plateau. Several roughly parallel mountain ridges cross the upper watershed in a northeast-southwest

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YOUGHIOGHENY RIVER WATERSHED
PENNSYLVANIA · MARYLAND · WEST VIRGINIA

NORTHEAST REGION 1
AUSTIN L. PATRICK
REGIONAL DIRECTOR

Fig. ~-1

Prepared by Regional Cartographic Division Upper Darby, Pa.

September 19..

direction. The valleys between the mountain ridges exhibit rolling to hilly topography. The lower 25 percent of the watershed is a rather deeply dissected plateau with rolling to hilly topography, and with steep slopes adjacent to the streams.

The Youghiogheny River and its larger tributaries are deeply entrenched in steep sided meandering channels. Stream gradients are generally steep; the main river falls from an elevation slightly over 2,500 feet in the headwaters to about 750 feet where it joins the Monongahela River.

Bedrock geology shows a typical interbedding of shales, sandstones and limestones in the lower 25 percent of the watershed. Elsewhere, shales and sandstones are interbedded, with considerable distortion due to uplifting and folding when the mountains were formed. Bituminous coal veins of varying thickness underlie practically all of the watershed.

The interbedding of shales and sandstones with limestone at varying depths has resulted in soils of medium texture which are best described as silt loams. Limited areas of sandy loam soils occur on the ridge tops, and at a few locations clay loam soils of limestone origin are found. The areas of clay loam and sandy loam soils are small and more or less isolated. The subsoil layers of practically all soils in the watershed are typical of those associated with silt loam surface soils of residual origin and, for this reason, the texture of all soils was considered to be silt loam.

Soils along or near the ridge tops are often shallow (profile of 20" or less). Along the lower slopes and in the valley bottoms the soil drainage is often inadequate although the actual area of poorly drained soils is small. For the purpose of hydrologic studies imperfectly and poorly drained soils are grouped with the shallow soils.

Economy

Mining of bituminous coal is one of the chief industries in the watershed. The lower watershed may be considered a part of the Pittsburgh industrial area. A small amount of coke is produced by the beehive oven method while much larger quantities are produced through by-product methods associated with the manufacture of steel. The watershed is served by several railroads, both main and branch lines, and by a network of highways.

Population of the watershed is estimated at 291,000. McKeesport, Connellsville and Greensburg, all in Pennsylvania are the largest centers of population and industry in the watershed.

Land Use

Open Land

In the vicinity of Oakland, Maryland, and in Somerset and Westmoreland Counties, Pennsylvania, there is extensive agricultural production centered around livestock, potatoes, and other field crops adapted to the region. Some parts of Westmoreland County have very good agricultural production; other parts are so

influenced by coal mining that little farming is attempted. In the higher and more mountainous portions of the watershed many areas show a subsistence type of agriculture.

Cropland, including hay, constitutes 22.4 percent of the watershed area and pastureland, 14.8 percent. The vegetative cover of much of the pastureland is inadequate resulting in rapid runoff and erosion. Crops are grown on many steep slopes where sheet and gully erosion are severe. Present land use and ownership are shown in table A-1.

Forest Land

Approximately 588,700 acres or 52 percent of the watershed area are forested. Farm woodlots account for 35 percent and private non-farm holdings 54 percent of the forest land area. The remaining 11 percent is in public ownership in the form of state forests, parks and game lands. No Federal ownership exists in the watershed.

The original stands of coniferous timber found throughout the watershed were cut by 1890. Logging of the remaining stands of hardwoods continued so that by 1926 practically no virgin timber remained. With the disappearance of the mature timber, logging of second-growth stands became a common practice. In fact, many of the young aged stands were repeatedly clear cut to meet the demands of the mining industry. These destructive logging operations were generally followed by severe fires.

In general the forests are in very poor condition. Evidence of the depleted condition of the present forest land is found in

the fact that seedling and sapling stands cover approximately 55 percent of the forest area, pole timber 44 percent, and sawtimber only 1 percent. In addition to the large distribution of young age classes, the stands are poorly stocked. Field surveys have indicated that present stands average only 50 percent stocked and vary from 10 to 60 percent.

Grazing is another factor contributing to the poor condition of the watershed's forest land. At present 53 percent of the farm woodlots, containing 18 percent of the total forest area, are being grazed. This practice directly affects runoff, destroying litter and reproduction, compacting the soil, and reducing the depth and the absorptive qualities of the forest floor.

A general classification of present stands indicates that oak types predominate. They represent 61 percent of the forest land area. Northern hardwoods follow with 38 percent, and softwoods, 1 percent.

The principal wood requirements of the watershed are for mine timbers, pulpwood, and lumber. These products account for approximately 93 percent of the annual drain. The remaining 7 percent is used for veneer, posts, and other miscellaneous products. By far the greatest utilization of available stumpage is by the coal mining industry. Of particular importance is the fact that practically no markets exist for other low quality material, such as fuel or chemical wood. Because of this, and the scarcity of high quality timber, returns to forest land owners are comparatively

small. Lack of available stumpage requires importation, particularly of high quality material, to meet the continuing demands of the basic steel and coal industries. However, under the recommended program of good forest management, the potential production of the watershed is probably sufficient to meet expected major local demands for wood products, and also provide a substantial volume for export to adjacent areas.

Table A-1. Major Use and Ownership of Land
Youghiogheny River Watershed

Ownership and Land Use	Watershed	
	(acres)	
Public		
State Owned Land 1/		64,777
Private		
Farm Land		
Openland	419,710	
Forest Land	203,614	
Other Land	31,935	
Total Farm Land		655,259
Non-Farm		
Forest Land	320,292	
Other Land 2/	87,372	
Total Non-Farm Land		407,664
TOTAL WATERSHED		1,127,700

1/ Includes 14,383 acres non-commercial forest land.

2/ Urban, water, rights-of-way, etc.

Climate

Temperature

The Youghiogheny Watershed experiences the relatively large fluctuations of temperature associated with an inland or continental location such as that of the Upper Ohio River area. Both synoptic and average temperatures vary to a considerable degree with elevation, decreasing from the vicinity of McKeesport and Pittsburgh, Pennsylvania to the higher elevations in West Virginia and Maryland. The average annual temperature at Pittsburgh, just outside the watershed, as determined from 79 years of Weather Bureau records is 52.8°F while that at Oakland is 5.1 degrees less, determined from a 52-year record. The average monthly temperatures, the extremes of recorded temperature and the average growing season for these two representative stations are shown by means of graphs in Figure A-2.

Precipitation

Precipitation, including rain and melted snow, averages 36.17 inches for the year at Pittsburgh and 46.73 inches at Oakland as determined from the Weather Bureau records mentioned above. Large accumulations of snow on the ground represent one of the flood hazards of this watershed. While the rate of snow melt, even under present watershed conditions, is rarely great enough of itself to cause serious flooding, such melting may be associated with heavy rainfall. Where large areas of the watershed are impermeable or have low infiltration rates due to concrete type freezing or other causes, such conditions are productive of extremely damaging floods.

This area is one where extremely high rates and amounts of rainfall may occasionally be expected. The U. S. Weather Bureau, after a cooperative study with the Corps of Engineers, has concluded that a thousand square mile area of the drainage above Pittsburgh may receive an average of nearly 10 inches of precipitation within a 12-hour period. This contrasts markedly with the normal monthly precipitation shown by graph in figure A-2. It should be noted that at neither of the representative stations does the normal amount of precipitation to be expected in any calendar month of the year even approach the amount which may be expected in half a day under unusual conditions. Figure A-3 shows the locations of precipitation stations in and near the watershed, and the locations of stream gaging stations on the Youghiogheny and its tributaries.

Flood Producing Conditions

Too frequent cutting of immature trees for use as mine timbers and railroad ties has resulted in unsatisfactory forest land cover over much of the area. Forest fires have occurred frequently in the past and their effects are still evident. The long steep slopes, often covered with a shallow and imperfectly drained soil mantle, have an inadequate vegetative cover and contribute maximum volumes of runoff to peak flows. In the early days of the coal and coke industry the common practice of converting coal to coke in beehive ovens liberated great quantities of smoke and resulted

CLIMATIC CONDITIONS - REPRESENTATIVE STATIONS

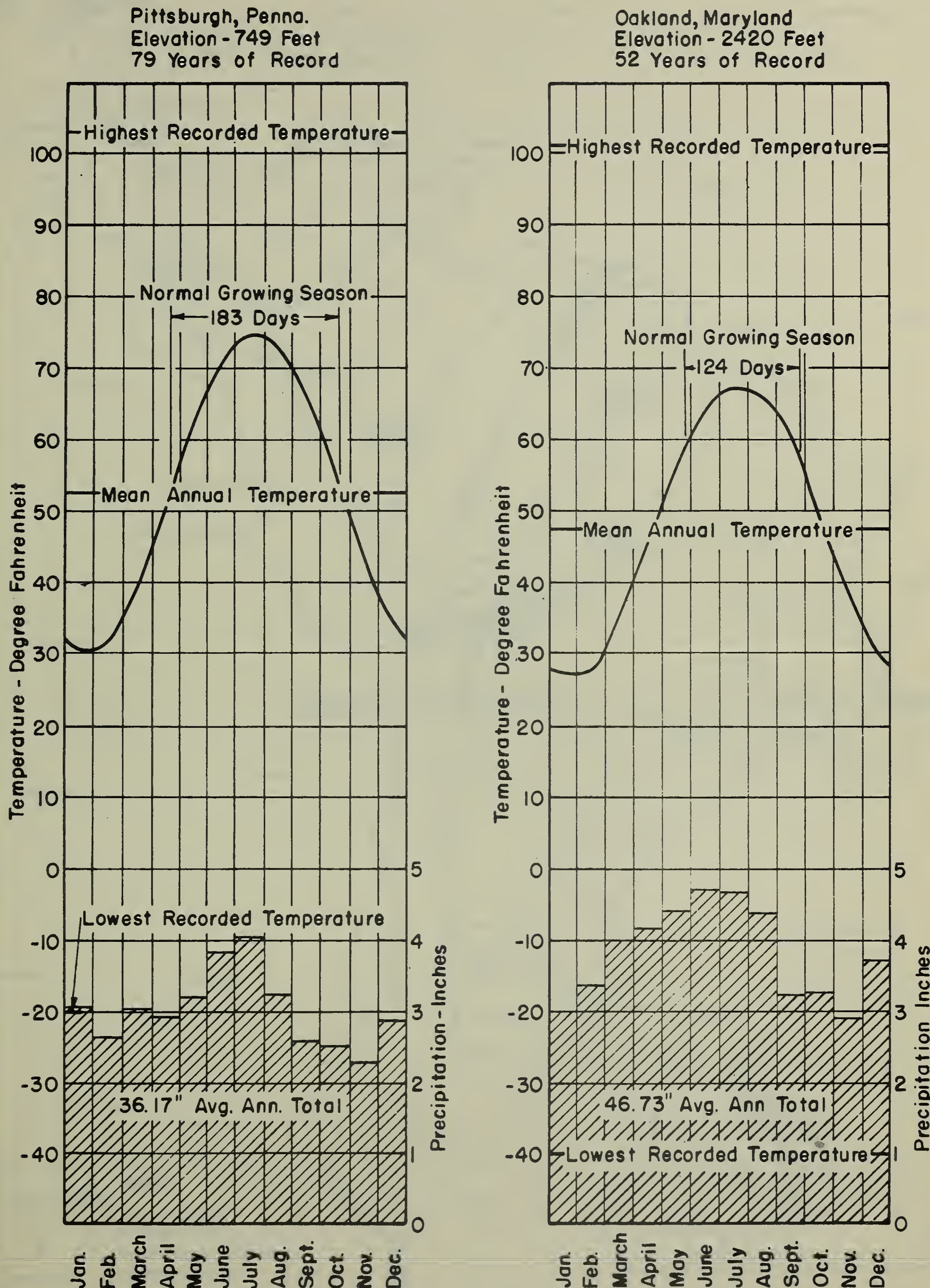

Fig. A-2

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HYDROLOGIC STATIONS
YOUGHIOGHENY RIVER WATERSHED
PENNSYLVANIA · MARYLAND · WEST VIRGINIA

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Fig. A-3

Prepared by Regional Cartographic Division Upper Darby, Pa.

September 1950

in the denuding of many steep slopes in the watershed. Acid from the smoke not only destroyed the vegetation but rendered the soil unfit for future vegetative growth. Such denuded slopes have not been adequately revegetated after at least two decades of relatively low beehive coke production.

Open farmland shows the effect of serious erosion. Many steep slopes are gullied, and many areas in the valleys have been damaged by deposition of eroded materials. Inadequate vegetative cover on pastured slopes and on the steeper cropland promotes rapid runoff and serious erosion.

Meteorological conditions that will produce floods may occur somewhere on the watershed during every month of the year. They are, however, most apt to produce floods on the main stem and larger tributaries during the winter and spring months. The smaller subwatersheds are more likely to be affected by flash flood producing thunderstorms during the summer growing season. There is no assurance, however, that this type of storm will not strike the watershed at any time of the year.

APPENDIX B

FLOOD SEDIMENT AND EROSION DAMAGE

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APPENDIX B. FLOOD, SEDIMENT AND EROSION DAMAGE

Flood Frequency

The Youghiogheny River has a long history of floods which have caused damages within and below the watershed. At Connellsville the highway bridge across the river was destroyed by flood in 1816. At this point the Youghiogheny has been gaged since 1888. Records of streamflow have also been made at fifteen other points in the Youghiogheny River system. The more important of these records are listed in table B-1 and the presently active stations are shown in figure A-3, table B-1. These records, and those on similar streams in the surrounding area, have been used in the determination of the percent chance of occurrence of flood flows of various magnitudes which may be expected from drainage areas ranging in size from two square miles to the entire area of the river basin. The generalized results from this investigation are presented graphically on figure B-1. In the making of this study the available record from each stream gaging station was examined in its entirety and all floods above a selected base tabulated for statistical analysis. Such floods were found to occur at all times of the year and, in a few cases, more than once in the same year.

Table B-1. Selected Stream Gaging Records
Youghiogheny River Watershed

Stream	Station Location	Drainage	Years of Record	Highest Recorded Instantaneous Discharge	
		(sq. mi.)		(c.f.s.)	(c.s.m.)
Youghiogheny River	Sutersville, Pa.	1,715	28	100,000	58
" "	Connellsville, Pa.	1,326	39	92,500	70
" "	Below Confluence, Pa.	1,029	7	43,800	43
" "	Confluence, Pa.	437	18	-	-
" "	Youghiogheny River Dam, Pa.	436	7	-	-
" "	Friendsville, Md.	295	23	-	-
" "	Oakland, Md.	134	6	3,780	28
Deep Creek	Sines, Md.	65	22	-	-
Green Lick Run	Green Lick Reservoir, Pa.	3.07	6	1,400	456
Laurel Hill Creek	Confluence, Pa.	126	9	-	-
" " "	Ursina, Pa.	121	34	10,300	85
Casselman River	Confluence, Pa.	450	9	-	-
" "	Markleton, Pa.	382	34	35,800	94
Big Piney Run	Salisbury, Pa.	24.5	15	4,300	176

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PENNSYLVANIA, MARYLAND, WEST VIRGINIA

NORTHEAST REGION I
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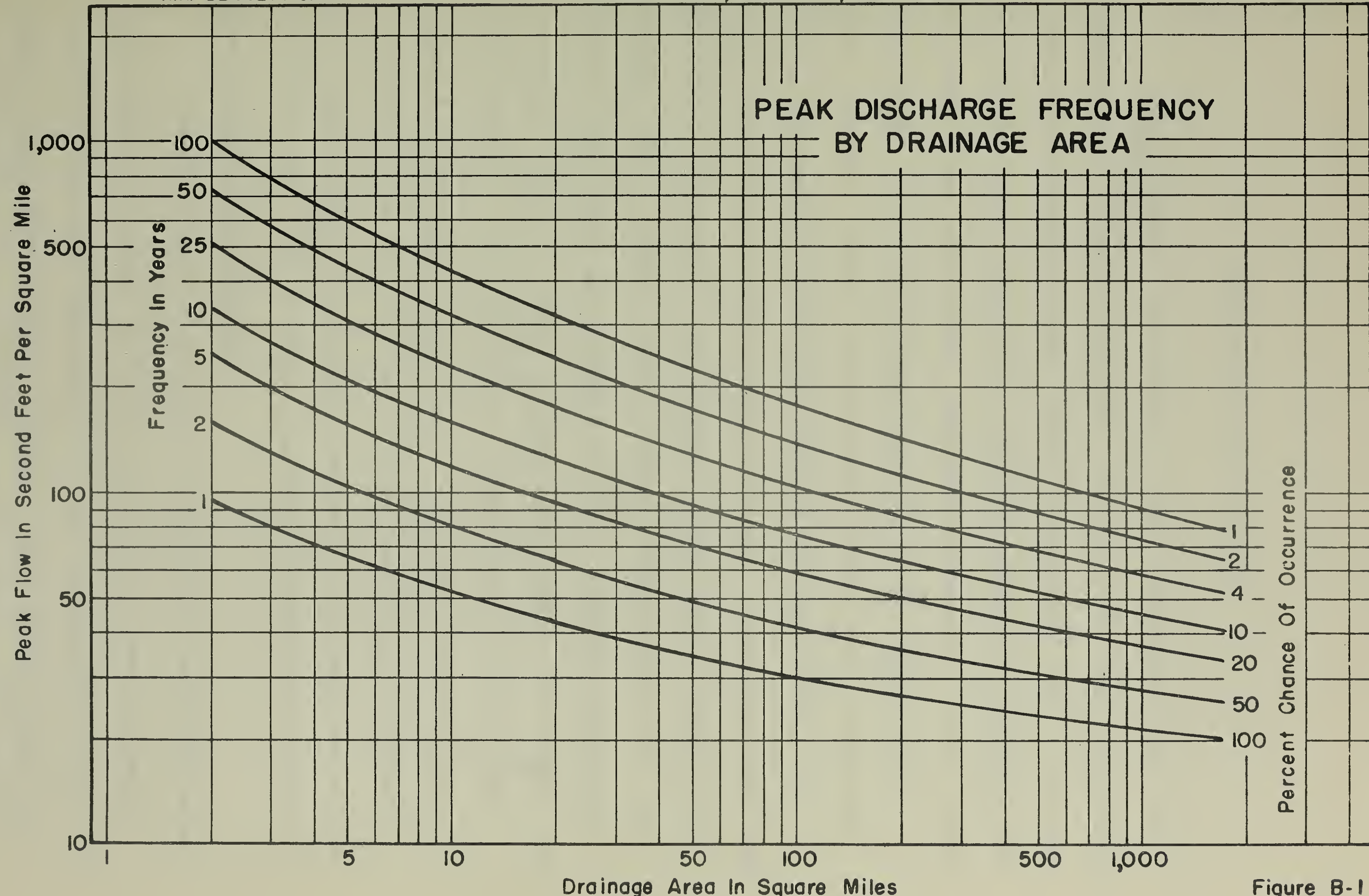

Figure B-1

Extent and Type of Damage

Flood Damage - Flood damages in the Youghiogheny River Watershed are of frequent occurrence. On some of the small tributaries, losses occur annually. These floods most commonly occur in the summer and the losses sustained are mainly to unimproved highways, and to growing crops and pasture. Much greater amounts of damage accrue from floods of rare occurrence in any one small drainage area. These floods are caused usually by very intense summer storms and do not necessarily create flood flows on the main streams. The August 1947 flood on Elklick Creek tributary of Casselman River near Myersdale, Pennsylvania, was typical of this kind of flood. The drainage area of Elklick Creek is about 17 square miles; the discharge of the flood was estimated to have a probable frequency of 100 years. Damages, mainly to unimproved highways and bridges, were about $15,000. Also illustrative of this kind of flood was the August 3, 1935 flood on Jacks Run, a tributary of Sewickley Creek. The drainage area of Jacks Run at South Greensburg, Pennsylvania, is 21 square miles; the probable frequency of discharge was estimated at 27 years; and the damages, mainly industrial and residential, were approximately $167,000.

Floods of general occurrence throughout the watershed cause more damage than either the annual flood or the severe infrequent localized flood. The March 1936 flood was the largest of any of the general floods ever recorded. Damages, based on 1949 values, exceeded $2,750,000 in the Youghiogheny River Watershed. Discharge

from the Youghiogheny River also contributed to the damage at points on the Monongahela and Upper Ohio Rivers.

Present day values (1949) of the total direct damages caused by the 1936 flood at downstream points are summarized as follows:

McKeesport District.	$ 11,577,000
Pittsburgh District.	219,394,000
Wheeling District.	57,887,000
TOTAL	$288,858,000

Average Annual Flood Damage

Average annual flood damages were determined by a comparison of the amount of damages caused by several floods varying in magnitude and are shown in table B-2. In each of the major streams, recurring damages were appraised for several floods of recent occurrence by interviewing owners of property affected by the floods. The damages were summated by floods for each stream, and related to flood frequency. Figure B-2, "Probable Frequency of Flood Damage, Casselman River", illustrates this relationship.

The percentage chance of occurrence was determined for each flood for which damages were estimated. The summarized damages by floods on each main stream were related to the probable frequencies of the floods, and expressed in graphic form as damage-frequency curves. From these curves the average annual damage was computed by determining the area under the curve and multiplying this by the

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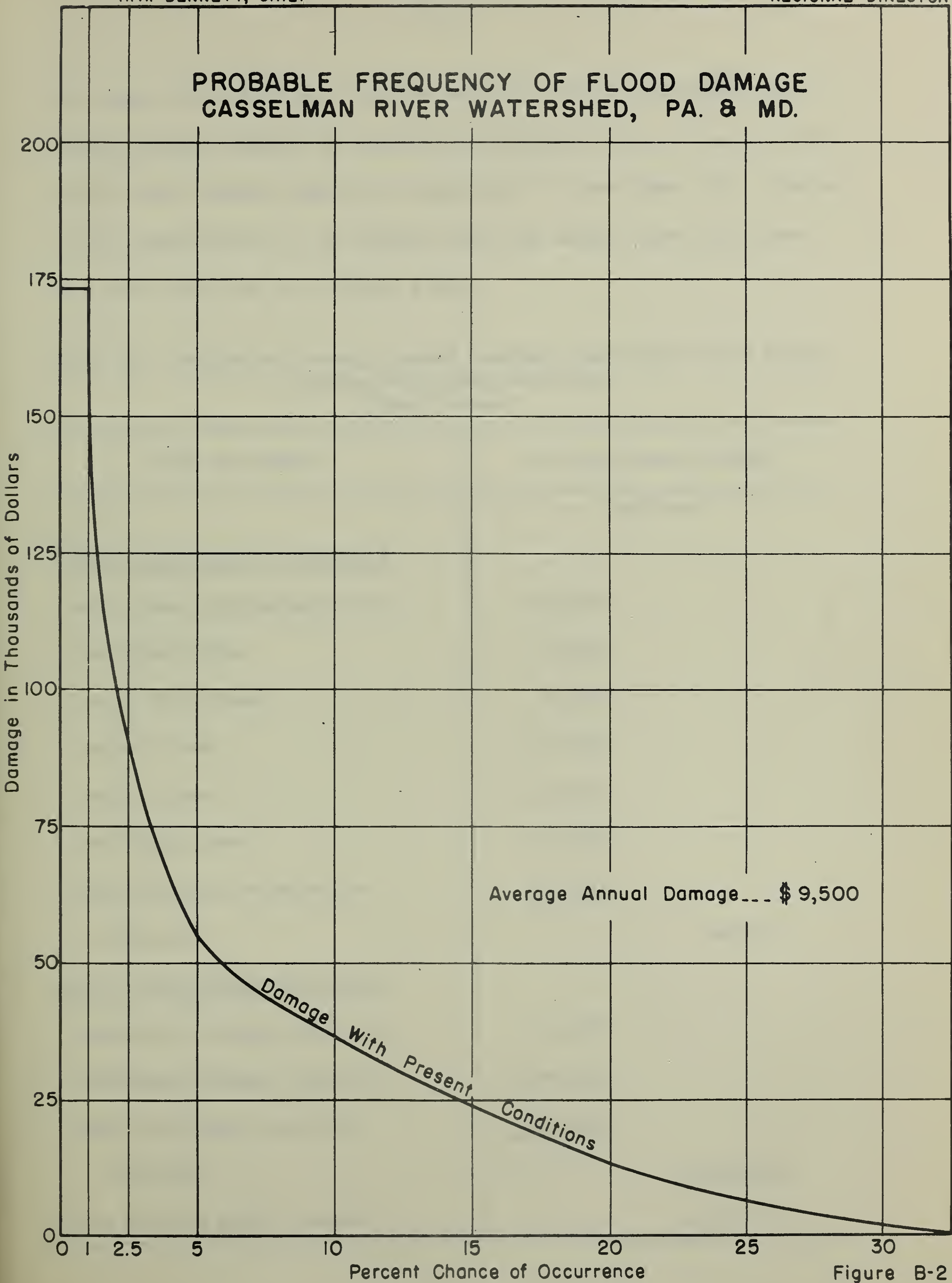

Figure B-2

unit area value obtained from the values of the coordinates. The average annual damage, as computed from figure B-2, is based on all floods where percent chance of occurrence is less than 100. However, in the computation, it is assumed that the damage does not exceed that shown for the one percent flood.

Table B-2. Estimated Average Annual Monetary Recurrent Flood Damage
Youghiogheny River Watershed
(1949 Prices)

Type of Damage	Average Annual Damage	
	(dollars)	
Within Youghiogheny Watershed		
Main Stem Youghiogheny River	20,400	
Casselman River	9,500	
Laurel Hill Creek	6,900	
Indian Creek	11,400	
Jacobs Creek	13,100	
Sewickley Creek	15,200	
Miscellaneous Tributaries	64,100	
Subtotal		140,600
Below Youghiogheny Watershed		
McKeesport Damage District	40,000	
Pittsburgh Damage District	1,186,500	
Wheeling Damage District	451,500	
Subtotal		1,678,000
TOTAL AVERAGE ANNUAL DAMAGE		1,818,600

On the smaller streams, with the exception of three, damages were determined by essentially the same procedure as that described above, but they were developed from an areal expansion of damages studied in representative sample watersheds. In selecting the sample tributaries to be studied, all of the small streams having drainages up to approximately 20 square miles were classified by their pertinent major physical characteristics, such as size of drainage area, stream gradient, extent of natural or artificial storage, and the existence of damageable property. For the watershed as a whole, 26 samples having drainage areas totaling 110 square miles were selected. The flood damages determined by the sample watershed studies are included in "Miscellaneous Tributaries" in table B-2.

The three exceptional streams referred to above are Jacks Run, Wilson Run and Snowy Creek and they were not represented by the samples because of relatively high flood damages. Damages in these three areas were not expanded to the total watershed.

Average annual damages on the main stem of the Youghiogheny River below the Youghiogheny River Reservoir were obtained through a different procedure. For this reach a record of flood stages at Connellsville, Pennsylvania, since 1895, was available. A graph showing the relationship of damages occurring on the main stem to flood stage at Connellsville, Pennsylvania, was obtained from the Department of the Army, Corps of Engineers. By use of this stage-damage curve, damages, based on 1949 values, were estimated for each flood experienced between 1895 and 1946. Average annual damages

were determined by dividing the total damage for the period by the number of years.

Discharge from the Youghiogheny River contributes to damages caused by flood stages below the mouth of the river to an extent greater than its drainage area would indicate. For example, of the March 1936 and March 1924 flood peaks at Pittsburgh, Pennsylvania, the Youghiogheny River contributed 17 percent and 23 percent of the discharge respectively. However, of the total drainage area above Pittsburgh, Pennsylvania, and Wheeling, West Virginia, the Youghiogheny River Watershed contains 9 percent and 7 percent respectively.

Eight flood control reservoirs, one of which is located in the Youghiogheny River Watershed, have been constructed and two others are under construction by the Department of the Army, Corps of Engineers, under various Congressional authorizations, which afford flood reduction benefits on the Ohio River system above Wheeling, West Virginia.

Average annual damages in the downstream damage districts of McKeesport, Pennsylvania, Pittsburgh, Pennsylvania, and Wheeling, West Virginia, were obtained by use of the following data, furnished by the Department of the Army, Corps of Engineers, and the U. S. Weather Bureau:

1. Effect of flood control reservoirs on peak stages by damage districts.
2. Stages of experienced flood events by damage districts.
3. Stage-damage relations by damage districts.

From the above data, damages were computed for each flood event recorded, based on 1949 values, and for a flood stage modified by the reservoirs. The residual damages were summarized for each damage district and divided by the number of years in the recorded period.

The average annual damages within the watershed and at points affected by the Youghiogheny River discharge are shown in table B-2. These damages do not include those which will be controlled by current Department of the Army, Corps of Engineers flood control operations.

Flood Damage Appraisal

Flood damages are commonly classified as direct and indirect. By direct damage is meant the physical destruction and loss resulting from direct contact with flood water while indirect damage includes all other losses associated with floods. The damages shown in the report include both direct and indirect, except for those evaluated from basic data furnished by the Department of the Army, Corps of Engineers on the main stem of the Youghiogheny River and at points below the watershed.

Indirect damages were not calculated separately, however they include such costs as evacuation and reentering premises, erecting temporary shelters, flood fighting, and higher costs of business operation. Other indirect losses included were the value of lost use of property during the period of restoration, and loss of labor to the extent that it was not accounted for by emergency work, such

as flood fighting, evacuating goods, cleaning up, etc. Those damages such as losses in the volume of trade through the reduced flow of goods from the flood area to the channels of trade and industry and through the decreased incomes of the owners of flood plain property were not evaluated. No monetary value was assigned to intangible losses, such as loss of life, illness, inconvenience, and disruption in social activities. Intangible damages were very large during and immediately following major floods, such as those in 1936, 1937 and 1942.

In estimating damages for specific floods, experienced flood damages were enumerated and used as the basis of appraisal. In those cases where a property was destroyed and not replaced, the damage was considered non-recurring and was, therefore, not used. In the case of a highway bridge destroyed and replaced by a structure capable of withstanding higher flood flows, the damage was considered non-recurring and modified downward to reflect the damage if the flood flow were to reoccur.

The amount of damage to growing crops varies with the season of inundation, depth and velocity of water, duration of inundation, and amount of deposition. Since flood damage to crops is relatively insignificant in the watershed, no detailed studies of these variations were made. In estimating damages for those instances where crops were subject to flooding, the above factors were considered along with data collected from farmers who had experienced recent crop damage. Information obtained from crop damage surveys in other watersheds was used where applicable.

Sediment Damages

Increased Maintenance Cost of Highways - Information relating to the type, amount, and occurrence of damage to highways by sedimentation was obtained from supervisors of State and Township roads. Sediment damage to highways is more often associated with local flash floods than with the large general floods. The losses are usually higher when the flood occurs during the early part of the growing season, May, June or July, when many of the sloping fields adjacent to the highways do not have sufficient protective vegetative cover. The amount of these damages is approximately $47,800 annually, about $12.90 per mile of public road. This estimate of highway damage does not include the costs of removing material which is deposited over a long period, because the source of this sediment may be mainly from the road bed itself. The appraised damage represents the losses accruing from preventable erosion.

Loss in Reservoir Storage Capacity - Surveys were made of seven reservoirs in the watershed to determine the extent of damage caused by sedimentation. The rate of silting was found to be very low. For two of the reservoirs studied the silting rate was so slight as to be immeasurable; in two others, the rate of reduction in storage capacity was 0.3 per cent annually; in one it was less than 0.1 percent; and in the other two reservoirs it was 0.5 percent and 1.1 percent respectively. The latter are channel type reservoirs, having capacity watershed ratios of 19 and 7 respectively, where the comparatively high rate of storage depletion results

principally from accumulated bedload material. The rate of sediment production, as indicated by measurements on these seven reservoirs, is in no case greater than 0.13 acre-foot per square mile annually.

The Youghiogheny River Reservoir, located on the main stem of the Youghiogheny River at Confluence, Pennsylvania, is the largest reservoir in the watershed. It was built by the Department of the Army, Corps of Engineers, under the general authorization for flood control reservoirs in the Ohio River Basin, contained in the Flood Control Act of June 28, 1938, and placed in operation in October 1943. The reservoir has a net drainage area of 429.4 square miles, a total storage capacity of 249,000 acre-feet, and was built at a cost of $9,000,000. It is used for purposes of flood control and regulation of streamflow for navigation and pollution abatement.

A survey made by the Corps of Engineers indicates that the rate of sedimentation in the permanent pool of the reservoir has averaged 0.06 percent per year for the six year period ending October 1949. It was considered that the monetary damage caused by this low sedimentation rate would be insignificant.

Water Treatment Costs - Studies were made of the effect of suspended sediment load in the Youghiogheny River at Connellsville, Pennsylvania, on costs of filtration. Additional costs of filtration, due to suspended sediment loads, were computed for four flood periods at Connellsville, Pennsylvania. Based on an estimated use

of 15.4 million gallons daily from the Youghiogheny River, the additional costs of water treatment are summarized as follows:

Flood Period	Maximum Turbidity	Additional Water Treatment Cost
	(parts per million)	(dollars)
August 1-12, 1935	85	460
March 10-23, 1936	200	645
Aug. 28 - Sept. 6, 1936	180	600
April 24-30, 1937	80	235

During normal flows the suspended sediment load, at points where water is taken from the river for domestic uses, is approximately 10 parts per million. This low turbidity does not increase filtration costs significantly.

Channel and Valley Sedimentation - Sediment damage is occurring in the valleys of some of the small tributaries. The most important of these tributaries are West Branch Coxes Creek and Upper Laurel Hill Creek. Deposition of sediment in the low gradient stream channels and on the adjoining bottomlands is one of the factors contributing to an increase in the stage and frequency of floods and intensification of land drainage problems.

Dredging Costs - The effect of sedimentation on maintenance costs of navigable stream channels was computed for the navigable portion of the Youghiogheny River. Approximately 10,000 cubic yards of deposited material in this channel is dredged annually. About one-half of the dredged material has its source in land

erosion. Based on a cost of $1.25 per cubic yard of deposits removed, the damage from land erosion is $6,250 annually.

Suspended sediment carried by the Youghiogheny River contributes to the dredging problem in the Monongahela and Ohio Rivers. However, when considering its contribution in relation to that contributed by the other watersheds, the damage would be relatively low, and was therefore not calculated.

Losses in Fish and Wildlife - The harmful effect of sediment on fish and wildlife has not been evaluated in monetary terms. The problem of evaluation is complicated and difficult because the pollution of waters is also caused by industrial and coal mining wastes. The benefits derived from reducing pollution and sedimentation caused by land erosion are, in part, dependent upon the reduction of pollution by other sources.

Erosion Damage

Damage to pasture lands caused by erosion was not calculated, because it is expected that going programs will establish within the 20-year installation period practically all of the soil conservation measures required to substantially control erosion. Based on studies of the Soil Conservation Service, the average annual rate of topsoil loss on all cropland is .06667 surface inches. Based on studies of the same source it was estimated that for each inch of soil eroded, yields of specified crops would decrease by varying amounts ranging from 3.2 to 10.0 percent. Present average yields, production and value of production for the area of cropland in the

watershed are shown in table B-3. These data apply to all lands regardless of variation of erodibility. Similarly, the rate of erosion used in determining the extent of damage is an average of all conditions.

The annual equivalent value of erosion damage is shown in table B-4. The loss is based on the assumption of yield declines; however, it may occur through other or combination of other changes, such as increased production costs in an effort to maintain yields, or lengthening crop rotations. The value of decreased production was accepted as a net loss, inasmuch as reductions in fertility mean little or no reduction in costs of raising the crop 1/. The value of the decline in crop production was assumed to represent the erosion damages up to the point of 20 percent reduction in yields. At this point changes may occur in farm management practices which would have a tendency to reduce the losses. The annual equivalent value of the erosion damage is $607,900.

Table B-3. Present Acreage of Crop Production and Values
Youghiogheny River Watershed

	Acres	Average Yield		Total Production	Unit Value	Value of Production
		Unit	Amount			
					(dollars)	(dollars)
Corn Grain	38,231	Bu.	39.6	1,513,948	1.44	2,180,085
Corn Silage	15,602	Ton	10.0	156,020	9.80	1,528,996
Wheat	25,361	Bu.	20.5	519,901	1.80	935,822
Oats	56,547	Bu.	32.5	1,837,778	.76	1,396,711
Hay	113,374	Ton	1.24	140,584	24.48	3,441,496
Potatoes	3,630	Bu.	180.0	653,400	1.55	1,012,770
TOTAL	252,745					10,495,880

1/ "One Method for Evaluating Effect of Measures to Prevent Erosion of Topsoil", by George H. Walter, AGRICULTURAL ECONOMICS RESEARCH, April 1950, Bureau of Agricultural Economics.

Table B-4. Expected Effect of Erosion on Value of Crop Production Without Land Treatment Measures Youghiogheny River Watershed

Crops and Pasture	Value of Present Production	Annual Soil Loss	Yield Decline Per Inch of Soil Loss	Annual Yield Decline	Duration of Decline Evaluated	Ultimate Annual Loss	Cumulative Annual Loss	Annual Equivalent of Loss 1/
	(dollars)	(inches)	(percent)	(percent)	(years)	(dollars)	(dollars)	(dollars)
Corn Grain	2,180,085	.06667	10.0	.6667	30	436,039	14,535	127,000
Corn Silage	1,528,996	.06667	10.0	.6667	30	305,814	10,194	89,000
Wheat	935,822	.06667	3.2	.213344	94	187,673	1,997	45,900
Oats	1,396,711	.06667	5.6	.373352	54	281,591	5,215	85,400
Hay	3,441,496	.06667	10.0	.6667	30	688,334	22,944	200,400
Potatoes	1,012,770	.06667	5.0	.33335	60	202,564	3,376	60,200
TOTAL	10,495,880							607,900

1/ Rounded to nearest hundred.

Summary of Damages

A summary of all evaluated recurrent damages in the watershed is shown in table B-5.

Table B-5. Estimated Average Annual Recurrent Monetary Damage
Youghiogheny River Watershed
(1949 Prices)

Type of Damage	Average Annual Damage	
	(dollars)	
Damage Due to Inundation		
Within Watershed	140,600	
Below Watershed	1,678,000	
Subtotal		1,818,600
Damage Due to Sediment		
Highways	47,800	
Dredging Costs	6,250	
Subtotal		54,050
Damage Due to Erosion		607,900
TOTAL AVERAGE ANNUAL DAMAGE		2,480,550

APPENDIX C

PROGRAM

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APPENDIX C. PROGRAM

Needs of the Watershed

The Lower Youghiogheny River Watershed is part of the highly industrialized and populated area adjacent to Pittsburgh, Pennsylvania. Flood runoff and sediment from the Youghiogheny Watershed contribute to local and downstream problems. Increasingly large quantities of water are needed to meet the demands of industries and urban communities.

The basic need of the watershed therefore is the establishment of an integrated runoff and waterflow retardation and erosion control program. Such a program will include land use adjustments, land treatment measures and practices, and additional structural measures installed primarily for flood and sediment reduction.

The component parts of a land program must be fitted to the capabilities and needs of the land and are influenced by the farm economy and cropping patterns, and the nature of the problems of flood and sedimentation. The kind, location, and extent of damages largely determine what structural measures can be effectively used.

Increased demands for water of good quality are practically basin-wide, and pollution is a serious problem in the downstream portions. This establishes the need for a coordinated watershed program in the interests of conservation and utilization of water.

Determination of Needs

<u>Land Treatment Measures and Practices</u>

<u>Openland</u> - Data from the 1945 U. S. Agricultural Census were

utilized to determine areas of openland devoted to different uses, numbers of farms, and numbers of livestock. This information was developed for gaged watersheds.

Detailed information on needed land use adjustments and land treatment measures and practices was secured from studies of conditions within sample areas. The sample areas were selected to represent the different agricultural conditions, soils, and general topography found in the watershed. Detailed soil conservation surveys of the sample areas were followed by the planning of land use changes and land treatment measures, as established by the capabilities of the soil.

The information collected from sample areas was used to determine total watershed needs by expansion to areas of similar soils and land use. A reconnaissance soil survey of the entire watershed supplemented by the information on land use established from the Census, provided the basis for this expansion. Minor adjustments in the watershed needs were made to conform with the estimated conservation needs and with conservation farm planning in nearby areas. At the time the original field survey was made there were no soil conservation districts established, although at the present time districts are operating in four of the six counties represented in the watershed. Farm plans prepared in these districts were not considered a representative sample for determining land use changes and land treatment measures. Total openland treatment needs of the watershed are shown in table C-1.

Table C-1. Total Watershed Needs

Youghiogheny River Watershed

Practice	Unit	Quantity
I. Land Treatment Measures and Practices		
Contour Strip Cropping	Acres	180,900
Cover Cropping	Acres	40,000
Diversions and Terraces	Miles	1,080
Outlets and Waterways	Acres	570
Establishing Perennial Hay	Acres	36,600
Pasture Improvement	Acres	98,600
Pasture Management	Acres	134,100
Contour Furrowing	Acres	48,800
Streambank Erosion Control	Miles	4
Erosion Control Structures	No.	1,400
Improved Forest Management	Acres	600,800 1/
Tree and Shrub Planting	Acres	43,800 2/
Public Land Acquisition	Acres	83,000
II. Additional Measures		
Stream Channel Improvement	Miles	30
Water Retarding Structures	No.	7

1/ Total future commercial forest area.

2/ Includes 6,600 acres of shrub planting.

Forest Land - The areal distribution of forest land was determined by utilizing data from the 1945 Agricultural Census. Distribution of stand size and condition classes was determined by a field survey of some 300 sample plots mechanically distributed over the watershed. These data, supplemented by discussions with local agencies, provided the basis for developing a picture of the present forest land situation and also indicated the remedial measures needed to correct present unsatisfactory hydrologic conditions. Total forest land treatment needs are shown in table C-1.

Local, state, and federal agencies contributed information and advice on the development of the program. Their present activities were taken into account in determining present and expected future needs. Type of ownership of forest land was determined since it has an important effect on program installation. At present 89 percent of the forest area is owned by private individuals and 11 percent by various public agencies.

A general rehabilitation program is needed in the forest land of the watershed. This includes the establishment of improved forest management practices, planting of trees and shrubs, and public acquisition of the portion of the area that is critical for watershed protection and which will not be rehabilitated by the present owners.

Additional Measures - The West Branch of Coxes Creek located to the west of Somerset, Pennsylvania, and the headwaters of Laurel Hill Creek were used as sample tributaries of the Youghiogheny River

Watershed to ascertain the present condition of the tributary stream channels and the kinds and amounts of channel improvement measures which would be effective in alleviating damages.

In general, the low gradient of these two tributaries and the high sediment production rate of the watershed above have brought about aggradation in the channel. This aggradation has resulted in some meandering and considerable impairment of existing drainage facilities in the bottomland along the main stems.

It was determined by a study of the costs of and resulting benefits from the required intermittent dredging and realignment work that approximately 15 miles of stream channel work on these two sample tributaries would return benefits in excess of costs.

The quantities, costs, and benefits, were projected to the watershed on the basis that the stream miles in the sample tributaries represented approximately one-half the stream miles requiring treatment in the watershed. This estimate was made from a study of existing soils data and field surveys.

Proposed sites for small water retarding structures were located by a careful study of the U. S. Geological Survey maps covering the watershed above all high damage points or reaches. It was possible from these maps to locate sites favorable for the construction of retarding structures of the type recommended and to determine drainage areas above the proposed structures. A topographic survey was made of each site selected, the structure designed, and its effect on the flood damage determined. (See Appendix D). Benefit-cost comparisons were then made for each structure

and for various combinations of structures above a damage point to determine the exact number of water retarding structures that would be included in the needs of the watershed.

Land Use Adjustments

Land use adjustments were determined for the watershed according to the needs and capabilities of the land. The use of such land treatment measures as contour strip cropping and diversions was also considered in determining the needed land use adjustments. These adjustments will provide substantial reductions in flood and sediment damages.

The land use changes needed involve, principally, reductions in acreages of clean tilled and grain crops, poor pastures, and grazed forests, and increases in acreages of hay, good pasture and good forest land. Actual changes in acreages of each land use, while dependent on capabilities, will also be influenced by such factors as location on the farm, field arrangements, stoniness and drainage condition of soil. Total needed land use adjustments are shown in table C-2.

Table C-2. Needed Land Use Adjustments

Youghiogheny River Watershed

Use of Land	Present	Future	Net Adjustments	
	(acres)	(acres)	(acres)	(percent)
Clean Tilled Crops	57,463	49,947	- 7,516	- 13.1
Grain Crops	81,908	69,263	- 12,645	- 15.4
Hay Crops	113,374	120,569	+ 7,195	+ 6.3
All Cropland	252,745	239,779	-12,966	- 5.1
Good Pasture	81,486	134,075	+ 52,589	+ 64.5
Poor Pasture	85,479	15,062	- 70,417	- 82.4
All Pastureland	166,965	149,137	-17,828	-10.7
Miscellaneous Openland	31,935	31,935	0	0
Grazed Forest Land	107,147	3,385	-103,762	- 96.8
Ungrazed Forest Land	481,536	616,092	+134,556	+ 27.9
All Forest Land	588,683	619,477	+30,794	+ 5.2
Impervious, Roads, Urban, Streams	87,372	87,372	0	0
TOTAL	1,127,700	1,127,700		

Activities Related to Flood Control

General Statements

Federal and state agencies are currently carrying on or aiding several programs which relate to flood control. Four agencies in the Department of Agriculture are active in this type of work; Production and Marketing Administration, Forest Service, Extension Service, and Soil Conservation Service.

The Production and Marketing Administration furnishes direct aids to individual farm owners for the application of many soil and water conservation measures and practices, such as the improvement of hay and pasture lands through lime and fertilizer applications, establishment of hay and pasture, construction of diversions and terraces, strip cropping, maintaining grassed waterways, the use of cover crops or mulching, tree planting, protection from grazing, and timber stand improvement.

The Forest Service cooperates with the states in promoting sound forestry practices. Through the Norris-Doxey Act, technical services in forest land management are furnished to farm forest land owners. Under the provisions of the Clarke-McNary Act financial assistance is furnished to states for fire protection and for production of tree seedlings to be distributed to land owners at low cost.

During the past four years the average percentage of protected area burned has been .24 percent in Pennsylvania, .11 percent in Maryland, and .68 percent in West Virginia. Only 4 percent

of the watershed is in West Virginia, and the standard of fire protection attained in the watershed in that State is better than the State average. On the whole, present protection is considered adequate for flood control purposes.

The Extension Service is cooperating with the State Extension Services which through their county agricultural agents and extension specialists are currently conducting an educational program in the counties of the watershed which is helping to increase the application of various land treatment practices and measures.

The Soil Conservation Service is furnishing technical services to soil conservation districts for the planning and installation of soil and water conservation practices and measures. Limited amounts of tree and shrub planting stock are furnished to districts.

Through these existing authorities the Department of Agriculture is now expending $86,000 annually in the Youghiogheny River Watershed to carry out these activities.

The Department of the Army, Corps of Engineers, has constructed a reservoir on the Youghiogheny River above Confluence, in the interests of flood control and navigation. This reservoir influences the runoff from about twenty-five percent of the total Youghiogheny drainage area and will reduce flood damages along the main stem of the Youghiogheny as well as on the Monongahela River at McKeesport, Pennsylvania, and along the Ohio River as far downstream as Wheeling, West Virginia and below. Operation of the reservoir in aid of navigation has increased low stream flows and has improved the quality of water to users downstream.

The Corps of Engineers is maintaining a navigable channel in the Youghiogheny River for a distance of 1.2 miles upstream from its mouth. This section is within the McKeesport City limits.

State and other local agencies administer certain lands in public ownership, predominantly forest land in state and municipal forests, parks, and game lands. In general, these lands are being managed in accordance with the aims and objectives of the recommended flood control program. In some cases, minor changes in management practice is necessary if these lands are to provide optimum watershed protection.

Soil Conservation districts organized under state laws, are operating in four of the six counties which make up the watershed. These districts have developed programs of proper land use and of soil and water conservation on farm lands.

Recommended Program

The following recommended program includes the intensification, acceleration, and adaptation of certain activities under current programs of the Department of Agriculture as described under "Activities Related to Flood Control" and additional measures, not now regularly installed but considered necessary to complete a balanced runoff and waterflow retardation and erosion control program for the watershed. The recommended program including land use adjustments, is deemed of primary importance to the objective of the flood control act and does not include measures or practices for the primary purpose of increasing production. For example, items such as: the application of fertilizer after the

installation or establishment of a measure has been completed; farm water supply and distribution systems exclusively for the purpose of livestock and domestic use; drainage and irrigation for increased production; tree planting or timber stand improvement for timber production only; and the installation of recreational facilities are not included as part of the recommended program.

The land treatment and additional measures are shown in table C-3, and are referred to throughout the report and appendices as the recommended program. The individual measures and practices are described below. Recommended land use adjustments are shown in table C-4.

Openland

The openland measures will reduce erosion and runoff through changes in land use and the adoption of improved cultural and management practices.

Contour Strip Cropping - This measure is the growing of hay or other close growing, soil conserving crops in alternate contour strips with clean tilled or soil depleting crops. Such a measure maintains at least half of the strip cropped fields in hay or close growing crops which will filter out eroded material and reduce sedimentation downstream. Contour cultivation, which is included with contour strip cropping in this report, is used to protect gently sloping land or small fields where strip cropping is not feasible. Contour cultivation and contour strip cropping reduce the rate and amount of runoff by increasing infiltration rates and by providing temporary surface storage. The removal of hedgerows or other

Table C-3. Recommended Program Measures

Youghiogheny River Watershed

Practice	Unit	Quantity
I. Land Treatment Measures and Practices		
Contour Strip Cropping	Acres	129,000
Cover Cropping	Acres	19,100
Diversions and terraces	Miles	960
Outlets and Waterways	Acres	190
Establishing Perennial Hay	Acres	28,900
Pasture Management	Acres	96,500
Contour Furrowing	Acres	48,700
Streambank Erosion Control	Miles	4
Erosion Control Structures	Number	970
Improved Forest Management	Acres	600,800 1/
Tree and Shrub Planting	Acres	38,400 2/
Public Land Acquisition	Acres	83,000
II. Additional Measures		
Stream Channel Improvement	Miles	30
Water Retarding Structures	Number	7

1/ Total future commercial forest area.

2/ Includes 5,800 acres of shrub planting.

Table C-4. Recommended Land Use Adjustments

Youghiogheny River Watershed

Land Use	After 20-Years' Going Programs	Recommended Program	Net Adjustments	
	(acres)	(acres)	(acres)	(percent)
Clean Tilled Crops	56,411	49,947	- 6,464	- 11.5
Grain Crops	80,138	69,263	- 10,875	- 13.6
Hay Crops	114,381	120,569	+ 6,188	+ 5.4
All Cropland	250,930	239,779	- 11,151	- 4.4
Good Pasture	88,848	134,075	+ 45,227	+ 50.9
Poor Pasture	75,621	15,062	- 60,559	- 80.0
All Pastureland	164,469	149,137	- 15,332	- 9.3
Miscellaneous Openland	31,935	31,935	0	0
Grazed Forest Land	92,620	3,385	- 89,235	- 96.3
Ungrazed Forest Land	500,374	616,092	+115,718	+ 23.1
All Forest Land	592,994	619,477	+ 26,483	+ 4.5
Impervious, Roads, Urban, Streams	87,372	87,372	0	0
TOTAL	1,127,700	1,127,700		

obstructions is necessary on many farms for proper installation of contour strip cropping. Some 129,000 acres are recommended for contour strip cropping.

Cover Cropping - This practice refers to the growing of temporary crops for the purpose of soil protection during off seasons for regular crops or during periods when the land would be idle or fallow. Cover cropping protects the soil from erosion by reducing the impact of rainfall, and reduces runoff through better infiltration conditions. This measure includes application of mulches, which are normally organic matter grown elsewhere and applied to critical areas. The organic matter added by cover cropping and mulching increases the water holding capacity of the soil. Cover cropping is recommended for some 19,100 acres.

Diversions and Terraces - Diversions and terraces are grouped as one measure since they have the same general function, intercepting surface runoff and carrying it across slopes in designed channels. Diversions are normally kept in perennial hay, while terraces are used for the same crop as the contiguous land. Both diversions and terraces are used in connection with strip cropping and contour cultivation, and, by removing excess surface water, facilitate the control of erosion by vegetative means. The removal of hedgerows and other obstructions is often necessary for the installation of this measure. A total of 960 miles of diversions and terraces are recommended for the watershed.

Outlets and Waterways - Natural drainage ways are used wherever possible for disposing of water from diversions and terraces. They are usually stabilized and protected by permanent grass cover. Where grass alone does not provide a safe cover, additional protective measures such as drop structures or lined flumes are used. Properly constructed and protected outlets and waterways will appreciably reduce erosion losses and sedimentation damage. The acreage of outlets and waterways recommended is 190. This figure was calculated on the basis that the outlet or waterway channel is 20 feet wide.

Establishing Perennial Hay - Vegetative cover consisting of long-lived legumes and grasses suitable for hay is recommended for those areas where clean tilled crops cannot be safely grown in rotation. Reseeding of the hay mixture will be done at infrequent intervals with as little cultivation of the land as possible. Perennial hay is also recommended for use in protecting diversions. Runoff will be reduced and erosion will be largely eliminated by adequate hay cover on present critical areas. This type of use and cover is recommended for 28,900 acres in the Youghiogheny basin.

Pasture Management - The objective of pasture management is the maintenance of adequate vegetative cover on land used for permanent pasture to reduce erosion and runoff. Mowing to control weeds and remove mature grasses, scattering of droppings, and regulating the intensity of grazing are essential to pasture management.

C

Additional fencing is usually required for adequate control of grazing. Certain areas of pasture land are rough or are partially covered by trees or brush. Where necessary these obstructions will be removed. Management of pasture to attain the objectives listed above is recommended for 96,500 acres.

Contour Furrowing - Level furrows or small level terraces with no outlets, are used for storage of water on pastured slopes where the vegetative cover is inadequate. Temporary storage, equivalent to one-half inch of runoff from the area treated, is provided by furrows of proper cross section and spacing. Permanent pasture areas recommended for treatment with contour furrows total 48,700 acres.

Streambank Erosion Control - Eroding streambanks on small tributary streams cause sedimentation damage downstream and loss of flood plain land adjacent to the streams. Erosion control for such banks involves sloping the banks and protecting them by mechanical means such as riprap or by suitable vegetation. Erosion control is recommended for almost four miles of small stream banks.

Erosion Control Structures - Included in this classification are such small structures as drop inlets, flumes, and culverts, used to protect waterways, outlets or other water disposal channels from gullying or other types of erosion. Where it is not feasible to use drop inlets or similar structures, protection is provided by channeling the water through flumes or culverts. The total of 973 structures recommended for construction in the Youghiogheny Watershed reflects the condition of steep eroding slopes with existing

or incipient gullies, and the inadequacy of present water disposal systems.

Forest Land

The purpose of the recommended program is to build up and maintain cover and soil conditions that provide and maintain optimum watershed relations on all forest land. Installation of the measures is expected to increase the infiltration rate and the water holding capacity of the soil. This will reduce surface runoff, stabilize soils, and prevent erosion.

Three general measures are proposed to meet the above objectives: application of improved forest management practices; increase in forest acreage by converting certain crop, pasture, and idle lands to forest land in accordance with the needs and capabilities of the land; public acquisition of critical watershed areas to insure necessary rehabilitation and continuity of management required to protect public interests. These are shown in table C-3.

On certain types of public lands some standards and practices are not in line with the objectives of this program. Where reorientation of objectives and improvement of practices on these lands are limited by finances, the necessary measures and funds are included in the recommended program.

Improved Forest Management - A management plan will be prepared for each property. This plan will integrate the dual objectives of watershed protection and timber production and will outline the important forest land management activities--such as planting, cultural operations, and harvest cuttings--to be carried out in order to maintain the forest land in the best possible condition for flood control and water conservation. Plans will be prepared for about 473,000 acres in private ownership and for 71,300 acres in public ownership.

Technical service will be provided to forest land owners and operators at public expense to mark timber for harvest cuttings and for cultural operations. Clear cutting over extensive areas will be eliminated as a harvesting method by substituting selective cuttings wherever applicable or by supplementing selective cuts with shelterwood, patch, group, or strip cutting where silviculturally necessary. It is estimated that approximately 473,000 acres of private land and 71,300 acres of public land will be marked for harvest cuts on a continuing basis. In addition, cultural operations will be outlined on approximately 110,000 acres of private land and 13,600 acres of public land during the installation period.

Corrective measures are needed on the present logging and skid road system to correct unstable conditions which lead to rapid runoff and excessive sediment movement. Such roads are often poorly located, have inadequate drainage facilities, and contribute excessively to flood runoff. Technical services will be provided for the proper planning and locating of the future road system and to outline the action to be taken to correct unsatisfactory conditions on existing logging roads. In addition, other federal aids will be made available for installation of water bars, ditches, culverts, and other structures needed to remove surface water from the roadway and spread it where it can enter the soil profile. Seeding, and in some cases fertilization, is needed to assure revegetation of roadways after use. Road stabilization measures will be applied as needed on the entire commercial forest area.

C

Cultural operations are needed to rapidly build up thrifty, well stocked stands which will create optimum forest land hydrologic conditions in the shortest possible time. Such operations will be confined to shallow soil areas where it is necessary to build up soil moisture storage capacities by increasing the depth of the humus layer and the amount of organic matter in the soil profile. Landowners are expected to carry out the needed operations.

Technical service and information in the field of utilizing and marketing forest products will be made available to land owners, logging operators and processors. This type of assistance will encourage land owners to adopt the recommended management practices and accomplish the objective of improving watershed conditions.

Livestock grazing will be eliminated on presently grazed forest areas and the area to be converted from openland to forest will be protected from grazing. Grazing control is an essential part of forest management. The program provides for the elimination of grazing on 126,200 acres of present forest and protection from grazing on approximately 31,000 acres of openland scheduled for conversion to forest.

Tree and Shrub Planting - Land use adjustments in accordance with need and capability will require conversion of openland to forest. Approximately 32,600 acres of present openland will be converted to forest by planting during the installation period. This area will be converted to forest while 6,100 acres of present forests are converted to openland, principally for pasture; resulting in a net gain of 26,500 acres in forest land area.

C

Shrubs will be planted on 5,800 acres. The planting of these shrubs in the edges between forest land and cultivated fields or pastures will provide good land cover in the partially shaded areas adjacent to forest land and aid in the reduction of surface runoff.

Public Land Acquisition - Acquisition of land by state and local governments is recommended only for land that is vital for watershed protection purposes. These areas are characteristically the ridge top and upper slope localities which, because of their location and past use, have poor forest land cover and contribute materially to flood problems. In general, these areas have suffered from repeated heavy cuttings and severe fires. Acquisition somewhat? of these areas will, however, be undertaken only if it is clear that the present owners will not carry out the improvement measures necessary to restore the land to good watershed condition. It is expected that land will be purchased by state or local governments and maintained as a part of existing or new public forests and preserves. Approximately 10,700 acres will be purchased as part of existing state and local parks and will not be classed as commercial forest land.

Acquisition of private land is recommended only in the States of Maryland and Pennsylvania. The approximate areal extents and locations are as follows: Maryland - the areas to be considered consist of approximately 10,000 acres in Garrett County. The forest cover consists principally of young and inferior oak stands.

Forest land hydrologic conditions are very unsatisfactory in the areas recommended for purchase. Pennsylvania - approximately 73,000 acres of the same type of land are recommended for purchase, largely in Fayette, Somerset and Westmoreland Counties.

Additional Measures

Stream Channel Improvement - The objectives of this measure are to reduce the damages resulting from inundation of valuable bottomland, provide outlets for drainage works, and furnish flood protection for high-value improvements, such as highways, railroads, bridges and farm buildings. To accomplish these objectives the capacity of stream channels will be increased by the removal of debris and sediment deposits, realignment, and bank sloping and the necessary adjacent field drains planned and installed.

Water Retarding Structures - The upstream floodwater retarding structures reduce inundation damage by providing temporary storage for runoff. Drainage areas above the structures average less than one square mile. These structures will be earth fill dams through which a small, low elevation outlet conduit uncontrolled by gates or valves will be constructed to draw down the temporary storage. A spillway adapted to site conditions and meeting required design criteria will be used to provide an outlet for flood flow in excess of designed storage capacity.

APPENDIX D

PHYSICAL EFFECT OF THE PROGRAM

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APPENDIX D. PHYSICAL EFFECT OF THE PROGRAM

Land Treatment Measures and Practices

Reduction in Flood Discharge

General - Flood discharge, most particularly peak discharge, on the Youghiogheny River and its tributaries, as on other rivers, is markedly affected by the type of land use and treatment to which the watershed is subjected. Land cover conversions, forest land management, and openland measures, as recommended in this report, result in an increase in the rate of infiltration and total amount infiltrated into the ground. The decreased surface runoff produces lower peak flows and reduces the damages due to inundation.

Forests - Forests influence runoff and erosion in various ways but the cumulative effect is largely reflected in the condition of the forest floor. Well stocked, thrifty stands normally have a good litter layer and a deep humus of porous texture which result in a higher rate of water intake and a greater water storage capacity. The influence of good forest floor conditions is also reflected by increased percolation rates and greater storage capacity in the underlying soil horizons. Also, the amount of concrete soil freezing will be greatly reduced with an increase in the depth and quality of the forest floor. This reduction in the area of impermeable frost will reduce surface runoff and increase the storage of ground water.

D

In order to evaluate the effect of the program measures a determination was made of the conditions under present stands and under well managed stands, such as would be obtained with the recommended program. On selected watersheds sample observations were made to determine the present average depth and condition of humus by stand size, condition class and past use. By past use is meant the treatment of the stands in regard to logging, burning, grazing and whether or not the land had previously been cleared for agriculture.

An analysis of these observations indicates that heavy cutting, burning and grazing greatly affect the depth and condition of the humus layers. Stands under these conditions have a shallow and compact humus. In some cases the humus has been completely destroyed. The well stocked stands which show no evidence of fire or grazing, and which have never been cleared for agriculture have a more porous and deeper humus and litter. The better present stands which are available for evaluating the recommended program do not, however, represent the best possible conditions.

For purposes of hydrologic analysis the forest land is divided into three evaluation classes based on the infiltration characteristics of the forest floor. These classes are as follows:

Evaluation Class I - Forest land with deep humus of a highly absorptive type. Forest floor undisturbed and uniform.

Evaluation Class II - Forest land with moderately deep humus of an absorptive type. Forest floor slightly disturbed but fully protected.

Evaluation Class III - Forest land with shallow humus, disturbed and patchy, or deeper humus of a compact, less porous type.

Openland

Infiltration and water storage on openland are functions of soil type, crop, and method of cultivation. Sandy soils and others with a large proportion of supra-capillary pore space are better able to take up the rainfall reaching the ground than are tight clay soils. This variation is accounted for in the soil classification of the watershed.

In somewhat similar fashion, the type of crop raised on a soil determines the hydrologic characteristics of a field. Crops of perennials and of those annuals which need not be reseeded each year offer the most desirable condition from the standpoint of infiltration and water storage, while at the other extreme, are the row crops with areas of bare soil cultivated during the growth of the crop. The effect of the program changes affecting this variable is illustrated under "Evaluation Class Conversion", which also accounts for present openland which will in the future become forest land and also for the improvement in woodland condition.

The third large variable in openland hydrologic condition is determined by the method of cultivation, contour planting, and other forms of "horizontal agriculture" offering the greatest opportunity for water to enter and remain in the soil, while greatest loss of water by runoff comes from up and down hill cultivation. The effect on this third variable by the program is accounted for under "Effect of Contour Measures on Detention Storage".

The openland hydrologic evaluation classes were established as follows:

<u>Evaluation Class IV</u> - Hydrologic conditions such as are found in good pasture. Highest openland infiltration. Includes good meadow or hayland.

<u>Evaluation Class V</u> - Infiltration and soil moisture transmission values of an intermediate openland condition. The hydrologic condition found with close growing crops such as small grains. Poor pasture and poor hayland were included in this class.

<u>Evaluation Class VI</u> - Poorest cropland hydrologic conditions. Runoff producing infiltration rates attributable to corn and other row crops.

<u>Other Areas</u> - Not all of the watershed is properly classifiable into the two main divisions, forest land and openland as these terms are used here. A small percentage of the watershed

area is given over to roads and urban development and a still smaller amount is covered by water, i.e., streams and lakes. Since this area total is small, much divided, highly variable and of nearly constant size, it has been assigned a runoff-infiltration relation value in lieu of a ϕ curve and an f_c value.

Included in "Other Areas" are roads, urban areas, water surfaces, and other small areas of low permeability.

Areas of Evaluation Classes

The present and future forest land areas in each condition class are shown in table D-1. The future Class I forest floor condition with the recommended program in effect is estimated to be the same as that found in present well stocked, ungrazed and unburned stands of older age classes.

Table D-1. Forest Land Evaluation Classes

Youghiogheny River Watershed

Class	Present		With Recommended Program	
	Acres	Percent	Acres	Percent
I	147,800	25	425,100	69
II	184,800	31	178,700	29
III	256,100	44	15,700	2

Openland evaluation class conversions are calculated on a total watershed area basis. Changes for the sample watershed will be found by comparing the columns headed "Area %" under "Present" and "With Recommended Program" in table D-5.

Changes in land use between various evaluation classes will result in the retirement of some openland to forest land, and the conversion within the openland to the classes having higher infiltration rates. Increased areas in evaluation Class IV will be derived almost entirely from areas now in Classes V and VI. The total net change will provide an improvement in hydrologic conditions as well as control soil erosion.

Reduction in Peak Discharge

The amount of reduction in peak discharge, due to land use conversions and additional forest land and openland measures, was calculated from watershed data on climatic, soil, and streamflow conditions. The individual steps followed are discussed below:

Infiltration - Infiltration data, derived largely from infiltrometer studies, were used to establish infiltration rates for the major soil and cover types found in the watershed. Each of the many soil types was assigned to one of three soil behavior groups according to its infiltration characteristics (table D-2). Applicable infiltration rates were assigned to each of the six evaluation classes as found on each of the soil groups. An example for the sample watershed is shown in table D-3.

The changes in infiltration rate during a storm were found to be most satisfactorily accounted for by the use of a ϕ curve

Table D-2. Soil Groups by Depth and Drainage
For Hydrologic Evaluation
Youghiogheny River Watershed

Soil Depth & Drainage	Soil Group	Representative Soil	Representative Soil Description	Other Soils
Shallow, well drained	1	DeKalb	Grayish-yellow to brownish-yellow silt loam surface with yellow subsoil. Acid and excessively drained. Developed on shales and sandstones on steeply rolling to hilly topography.	Gilpin, Calvin, Meigs
Deep, well drained	2	Westmoreland	Yellowish-brown silt loam with silty clay loam subsoil. Acid to alkaline and well drained. Developed on shales, sandstones, and limestones on gently rolling to steeply rolling topography.	Clymer, Rayne, Upshur
Imperfectly to poorly drained	3	Wharton	Grayish-yellow heavy silty clay loam surface with pale yellow silty clay subsoil. Subsoil is mottled at depth of from 18 to 30 inches. Developed on shales and sandstones on gently rolling topography.	Lickdale, Cavode, Ernest, Philo, Atkins, Linsdale

Table D-3. Infiltration Rates

Values of f_c in inches per Hour at 600 Minutes

Casselman River Watershed, Pennsylvania

Youghiogheny River Watershed

Evaluation Class	Soil Group		
	1	2	3
Class I (Forest Land)	0.140	0.105	0.070
Class II " "	0.100	0.075	0.050
Class III " "	0.090	0.070	0.045
Class IV (Openland)	0.100	0.075	0.050
Class V "	0.090	0.070	0.045
Class VI "	0.080	0.060	0.040

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[illegible]	[illegible]		[illegible]		
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

for each evaluation class (figure D-1). A ⌀ curve differs from a curve of infiltration rate in that any point on the ⌀ curve represents an average value for the infiltration that has taken place from the beginning of precipitation to the time designated by that point. These curves of necessity represent average conditions for the evaluation class but their use permits a satisfactory analysis of the runoff producing conditions of the watershed. The ⌀ curves were used in the analysis of runoff from a series of storms developed for each area considered.

Land Use Changes - The procedure used in determining the amount of peak flow reduction to be expected from land use changes and other program measures follows a logical series of steps consisting of statistical and graphical analyses applied to the principal factors affecting flood damages. These steps are described below.

Sample tributaries for determining the hydrologic effect of the program were selected to best represent conditions within the watershed. The samples are the watersheds above the gaging stations listed as follows:

Laurel Hill Creek at Ursina, Pennsylvania, Big Piney Run near Salisbury, Maryland, and Casselman River at Markleton, Pennsylvania.

A series of flood producing storms covering the range from minimum to maximum damage was composited for use on each of the sample subwatersheds. Published and unpublished records of precipitation amounts and intensities, furnished largely by the

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PENNSYLVANIA-MARYLAND-WEST VIRGINIA

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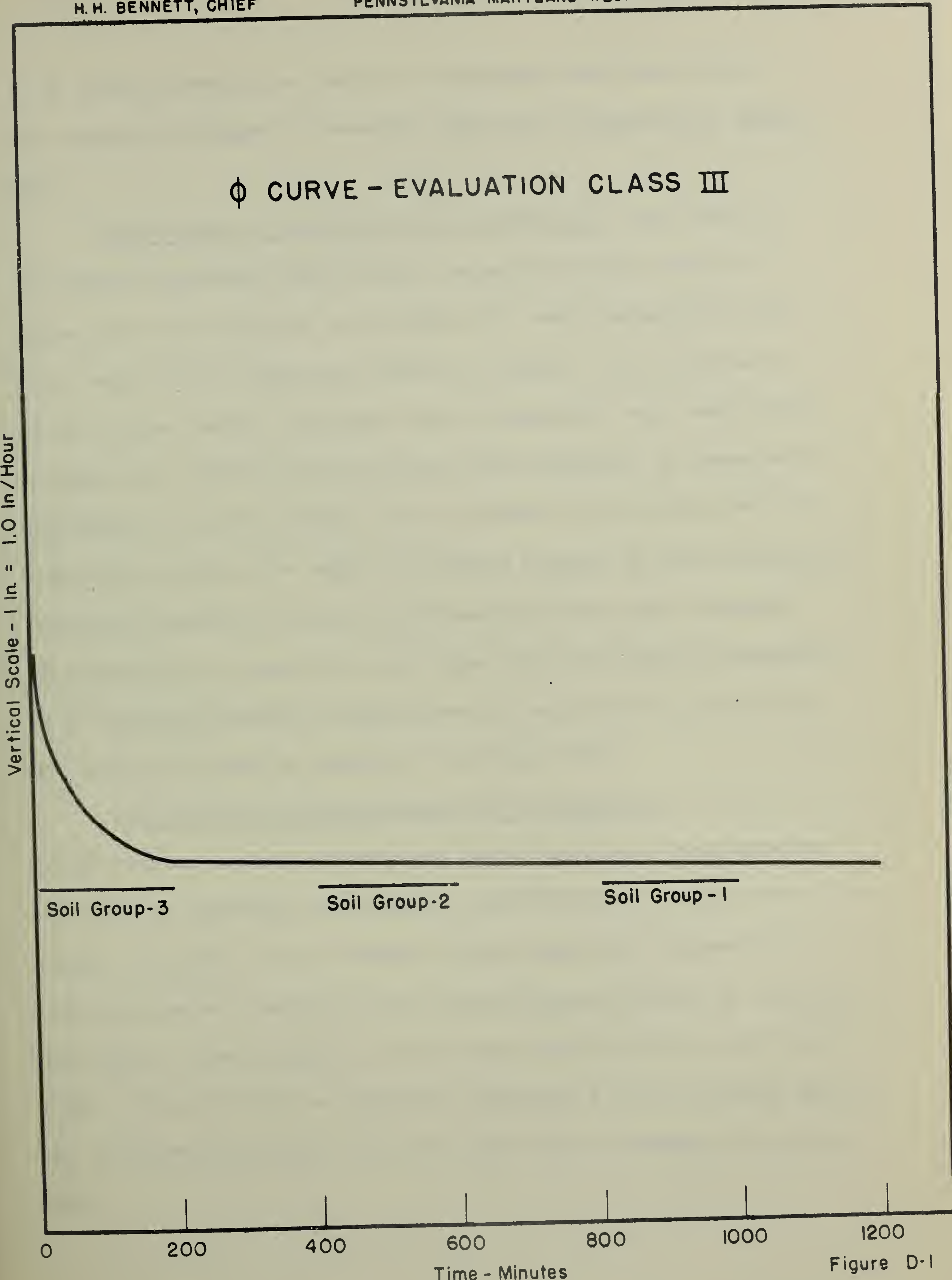

Figure D-1

U. S. Weather Bureau, were used in determining the storm values. The procedure followed is described below and illustrated in figure D-2.

Relationship of Discharge (Q) to Runoff (Y) - For each of the sample watersheds United States Geological Survey records of stream flow were utilized to determine the peak discharge and surface runoff for all important floods of record. For determination of the latter factor, individual flood hydrographs were constructed on which were plotted curves of base flow assignable to ground water accretions. The area between the two curves was determined and its value in watershed area depth was plotted against the peak discharge. The curve showing the average relationship between peak discharge (designated Q) in second-feet per square mile and runoff (designated Y) in equivalent depth in inches over the watershed was drawn from the series of points so plotted. See figure D-2a.

Relationship of Precipitation (P) to Runoff (Y) - U. S. Weather Bureau records of daily and hourly amounts of precipitation were used to determine the rainfall contributing to the peak discharge. Rainfall at the stations in and immediately adjacent to the watershed was weighted by the Horton-Theissen method to determine the average inches depth on the watershed contributing to the flood crest. Precipitation so determined (designated P) was plotted against the corresponding runoff (Y) in the same unit of measure. See figure D-2b.

HYDROLOGIC RELATIONSHIPS
CASSELMAN RIVER WATERSHED, PA.

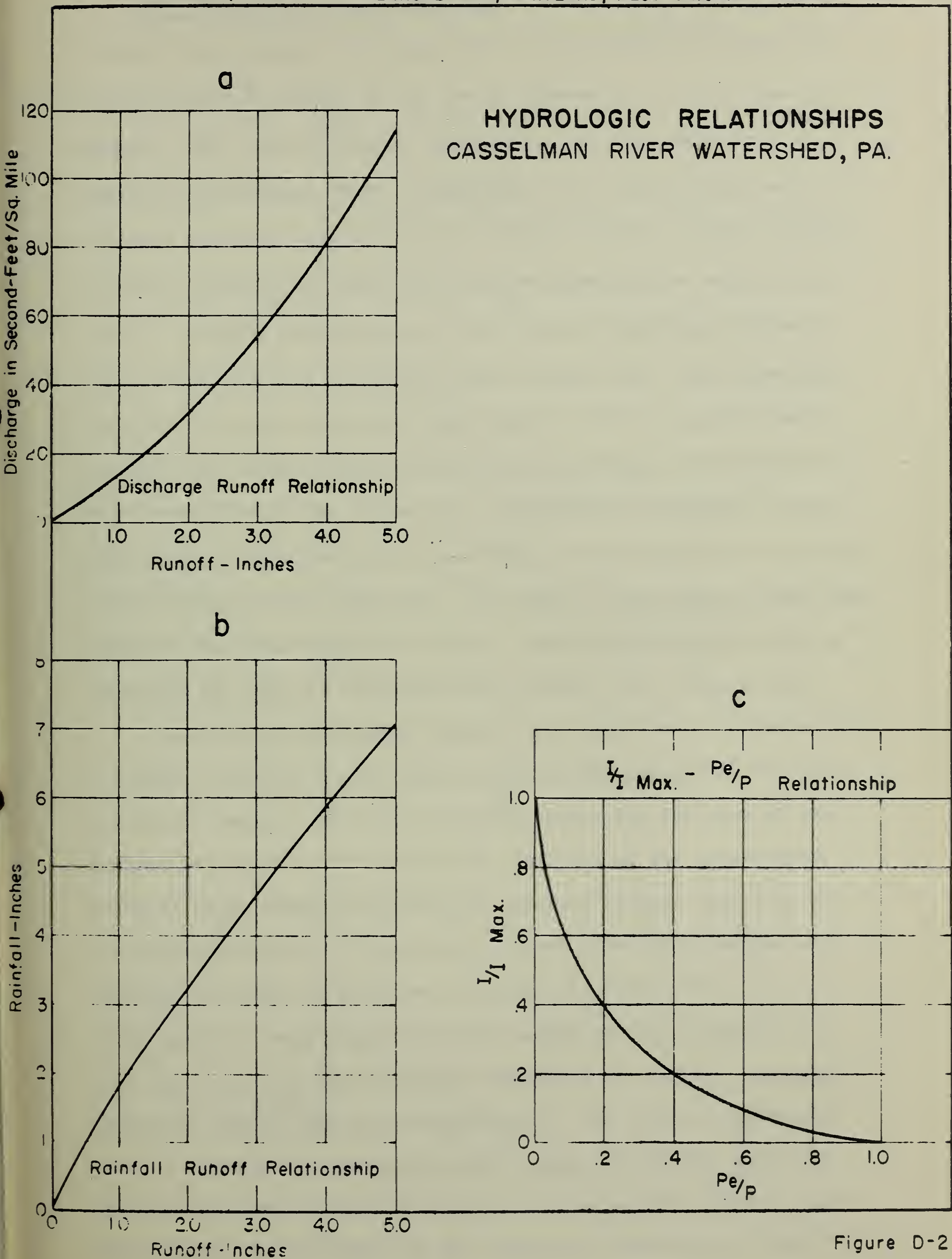

Figure D-2

<u>Relationship of Pe/P to I/I max</u> - This relationship was determined from 5-minute intensity data of 44 storms at Binghamton, New York, and 81 storms at St. Louis, Missouri, in the following manner: The actual 5-minute intensities for each storm were arranged in descending order of magnitude. For every storm each individual 5-minute intensity (I) was divided by the storm's maximum 5-minute intensity (I max), and the corresponding Pe values (quantity of rainfall falling at or above the corresponding intensity) were each divided by the total storm rainfall (P), thus providing two sets of ratio values that were plotted I/I max against Pe/P. A curve, for each station, indicating the average relationship was drawn resulting in two curves on a dimensionless diagram. The graphic mean of these two curves was taken as the normal I/I max-Pe/P relationship for the watershed. The slope of this curve (N)was determined from its tangent at several representative points and is expressed in units of abscissa over ordinate. See figure D-2c.

The above relationships provided the basis for development of a series of project storms correlating discharge, precipitation, runoff and maximum intensity. Maximum intensity for each of the project storms was determined by an analysis of the experienced rainfall rates found during many historical storms. For each of the project storms a Pe curve and a storm intensity diagram were computed as shown in table D-4 and plotted, figure D-3. The Pe curve shows at each point the total amount of rain falling at a rate equal to or greater than the indicated intensity, a quantity sometimes called "excess precipitation". The time on the storm pattern shows for any intensity the length of time for which an equal or greater rainfall rate prevailed during the storm. These time values are designated by the symbol Te (duration of time of excess).

Table D-4. Pe - Storm Pattern Work Sheet

Youghiogheny River Watershed

Sample Watershed - Casselman River
at Markleton, Pennsylvania

Storm No. 3

Q = 20,000 second ft. P = 4.51 inches I max = 6.19 in/hr. Y = 2.93 inches

T = 5.4783 hours = 329 minutes $\frac{T}{3}$ = 1.8261 hours $\frac{P}{I\ max}$ = .7285945

$\frac{I}{I\ max}$	$\frac{Pe}{P}$	N	I	Pe	Te	$\frac{2Te}{3}$	$\frac{T}{3} + \frac{2Te}{3}$ (hours)	$\frac{T}{3} + \frac{2Te}{3}$ (minutes)
1.0	0	0	6.19	0	0	0	1.8261	110
0.9	.014	.162	5.57	.0631	.1180	.0787	1.9048	114
0.8	.032	.230	4.95	.1443	.1676	.1117	1.9378	116
0.7	.059	.307	4.33	.2661	.2237	.1491	1.9752	119
0.6	.094	.406	3.71	.4239	.2958	.1972	2.0233	121
0.5	.140	.500	3.10	.6314	.3643	.2429	2.0690	124
0.4	.200	.681	2.48	.9020	.4962	.3308	2.1569	129
0.3	.280	.903	1.86	1.2628	.6579	.4386	2.2647	136
0.2	.395	1.474	1.24	1.7815	1.0739	.7159	2.5420	153
0.1	.587	2.538	.62	2.6474	1.8492	1.2328	3.0589	184
0.05	.738	3.765	.31	3.3284	2.7431	1.8287	3.6548	219
0.00	1.000	7.519	0	4.5100	5.4783	3.6522	5.4783	329

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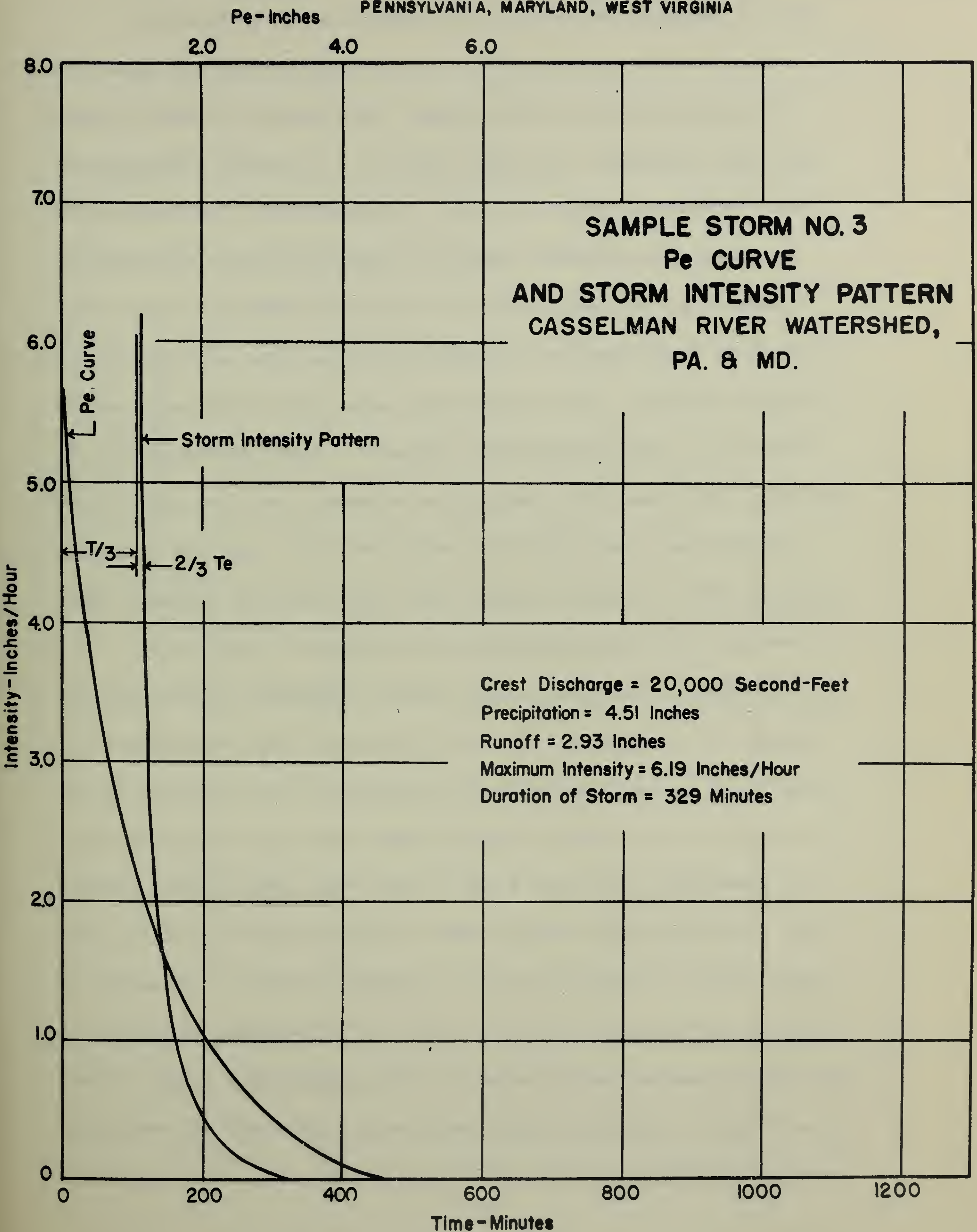

Figure D3

Storm No. 3 for Casselman River Watershed produces a peak discharge of 20,000 second-feet (or 52.4 second-feet per square mile) as shown in table D-3. Based on this peak discharge, the corresponding values of Y, P, and I max were determined from the above-described relationships. From the average discharge-runoff relationship a peak discharge of 20,000 second-feet accompanies 2.93 inches of runoff; from the P-Y curve, 2.93 inches of runoff is derived from 4.51 inches of rainfall; an analysis of historical storms shows that 4.51 inches of rainfall have a maximum intensity of 6.19 inches per hour. From the I/I max-Pe/P curve, the values Pe/P (table D-4) were taken to correspond with each of the selected values of I/I max. Both table D-4 and figure D-3 show that the total rainfall of 4.51 inches fell during a period of 329 minutes.

The Pe and Te diagrams, in conjunction with the ϕ curves for the several evaluation classes make possible the evaluation of the recommended land conversion phase of the program. To obtain the Pe value for each evaluation class and soil group, the ϕ curve was superimposed upon the storm pattern so that the base lines coincided and the zero time line of the ϕ curve was positioned on such a time line that computed runoff agreed with measured. The Pe values for a given evaluation class were found on the Pe scale horizontally opposite to the point of intersection of the ϕ curve and Te curve. Multiplying this Pe value by the percent of the tributary area in that evaluation class (table D-5) gave a runoff value for that class. The summation of these values for all the classes

Table D-5. Runoff Reduction Determination -

Evaluation Class Conversion

Youghiogheny River Watershed

Casselman River Watershed at Markleton, Pa. D. A. 382 Sq. Mi.

Storm No. 3 P = 4.51 in. Y = 2.93 in.

Coincidence at 105 min. Qp = 20,000 sec.-ft.

Soil Group	Evaluation Class	Present Conditions			Recommended Program	
		Area %	Pe	% In.	Change in Area %	Change in % In.
1	I	3.38	2.03	6.86	7.64	15.51
	II	4.18	2.41	10.07	0.55	1.33
	III	5.94	2.77	16.45	(-) 5.94	(-) 16.45
	IV	9.95	3.00	29.85	2.93	8.79
	V	11.61	3.45	40.05	(-) 4.61	(-) 15.90
	VI	4.42	3.68	16.27	(-) 0.57	(-) 2.10
2	I	9.09	2.13	19.36	16.52	35.19
	II	11.26	2.50	28.15	(-) 0.50	(-) 1.25
	III	15.99	2.86	45.73	(-) 15.21	(-) 43.50
	IV	0.18	3.07	0.55	0.39	1.20
	V	1.75	3.52	6.16	(-) 1.20	(-) 4.22
	VI	-	-	-	-	-
3	I	1.73	2.22	3.84	3.74	8.30
	II	2.15	2.59	5.57	0.06	0.16
	III	3.04	2.99	9.09	(-) 2.60	(-) 7.77
	IV	4.47	3.14	14.04	1.75	5.50
	V	5.27	3.62	19.08	(-) 2.83	(-) 10.24
	VI	1.19	3.81	4.53	(-) 0.12	(-) 0.46
	Other	4.40	3.83	16.85	0.0	0.0
	TOTALS	100.0		292.50		(-) 25.91

Table D-5. (Cont.) Runoff Reduction Determination -

Effect of changes in evaluation classes - $\frac{25.91}{292.50}$ = 8.86 % reduction

Effect of increased humus on detention storage:

Evaluation Class	Average Inches Humus Depth	% Area		% Area Change	Depth-% Area Change
		Present	Program		
I	2.95	14.20	42.10	+27.90	+ 82.31
II	1.95	17.59	17.70	+ 0.11	+ 0.21
III	0.79	24.97	1.22	-23.75	-18.76
TOTAL					63.76

Total Depth-% Area Increase = 63.76 x .05" (detention storage of increased humus) = 3.19 % inches.

Effect of contour measures on detention storage:

16.79% area x .05" = 0.84% inches

Summary:	Storage (% inches)	Runoff (% inches)
Present condition of runoff		292.50
Effect of changes in evaluation classes	25.91	266.59
Effect of increased forest land humus on detention storage	3.19	263.40
Effect of contour measures on detention storage	0.84	262.56

Total effect of recommended land treatment program:

$$\frac{292.50 - 262.56}{292.50} = 10.24\%$$ Reduction in Volume of Runoff

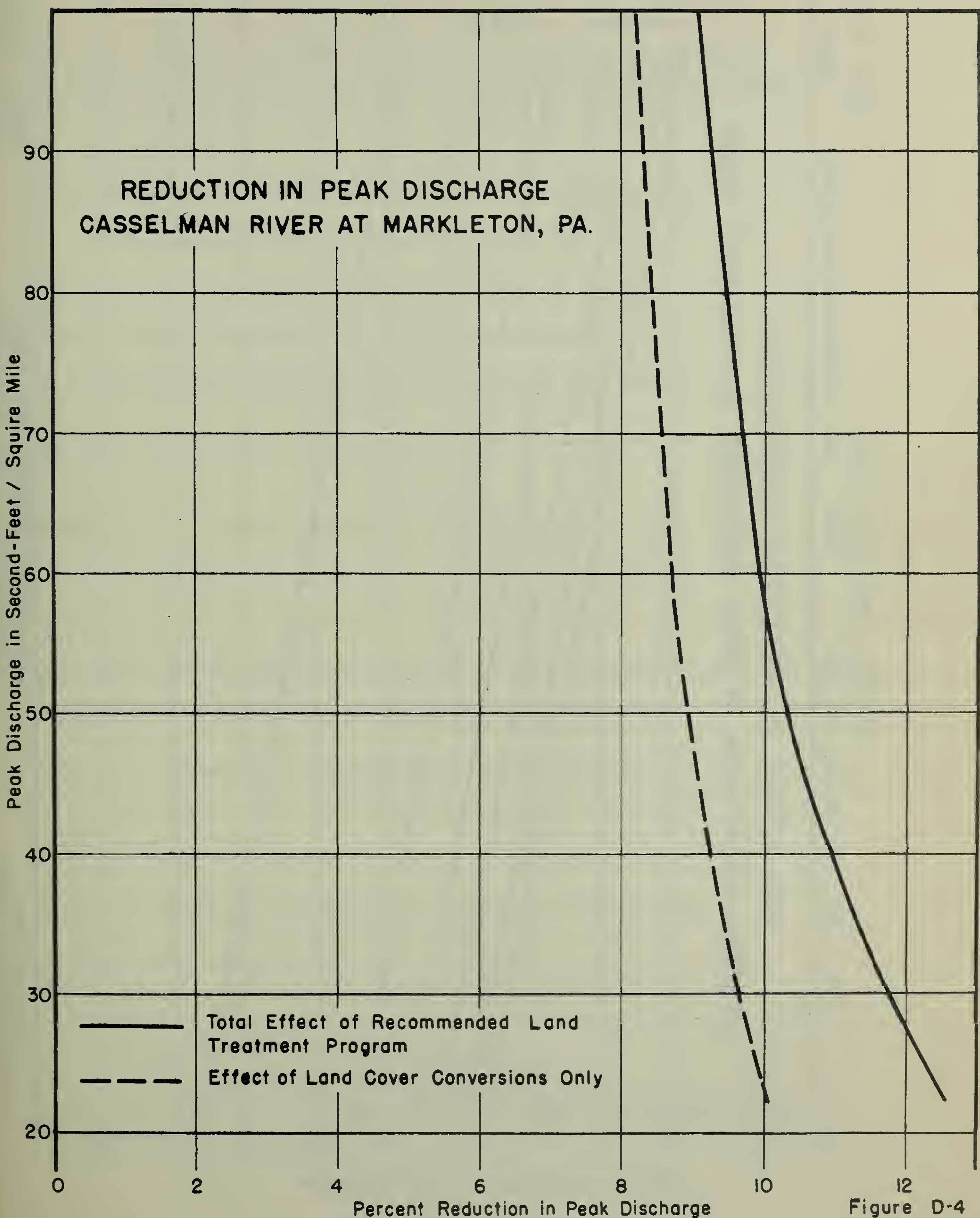
REDUCTION IN PEAK DISCHARGE
CASSELMAN RIVER AT MARKLETON, PA.
Peak Discharge in Second-Feet / Squire Mile
90
80
70
60
50
40
30
20
0
2
4
6
8
10
12
Percent Reduction in Peak Discharge
Total Effect of Recommended Land Treatment Program
Effect of Land Cover Conversions Only

Figure D-4

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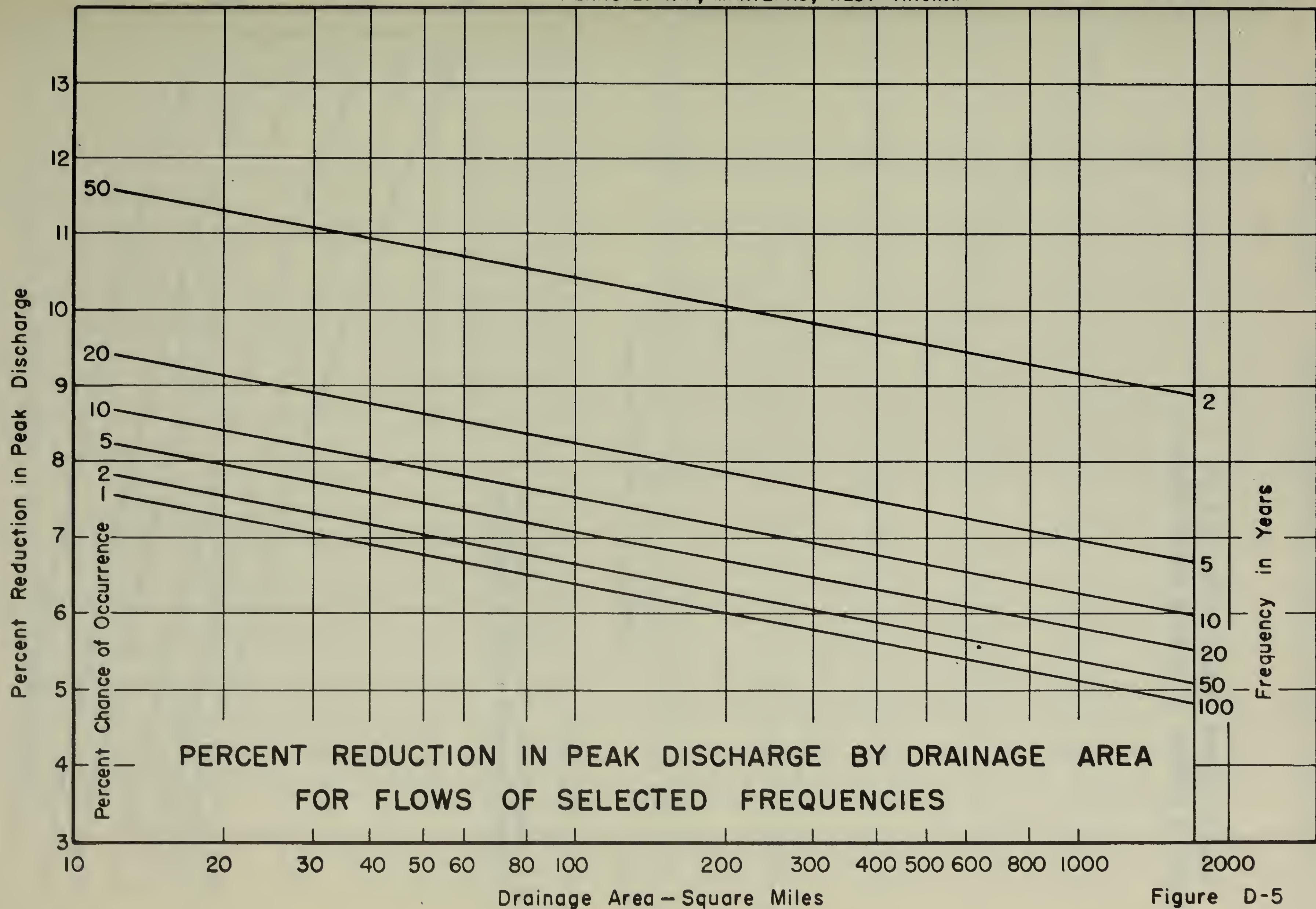

Figure D-5

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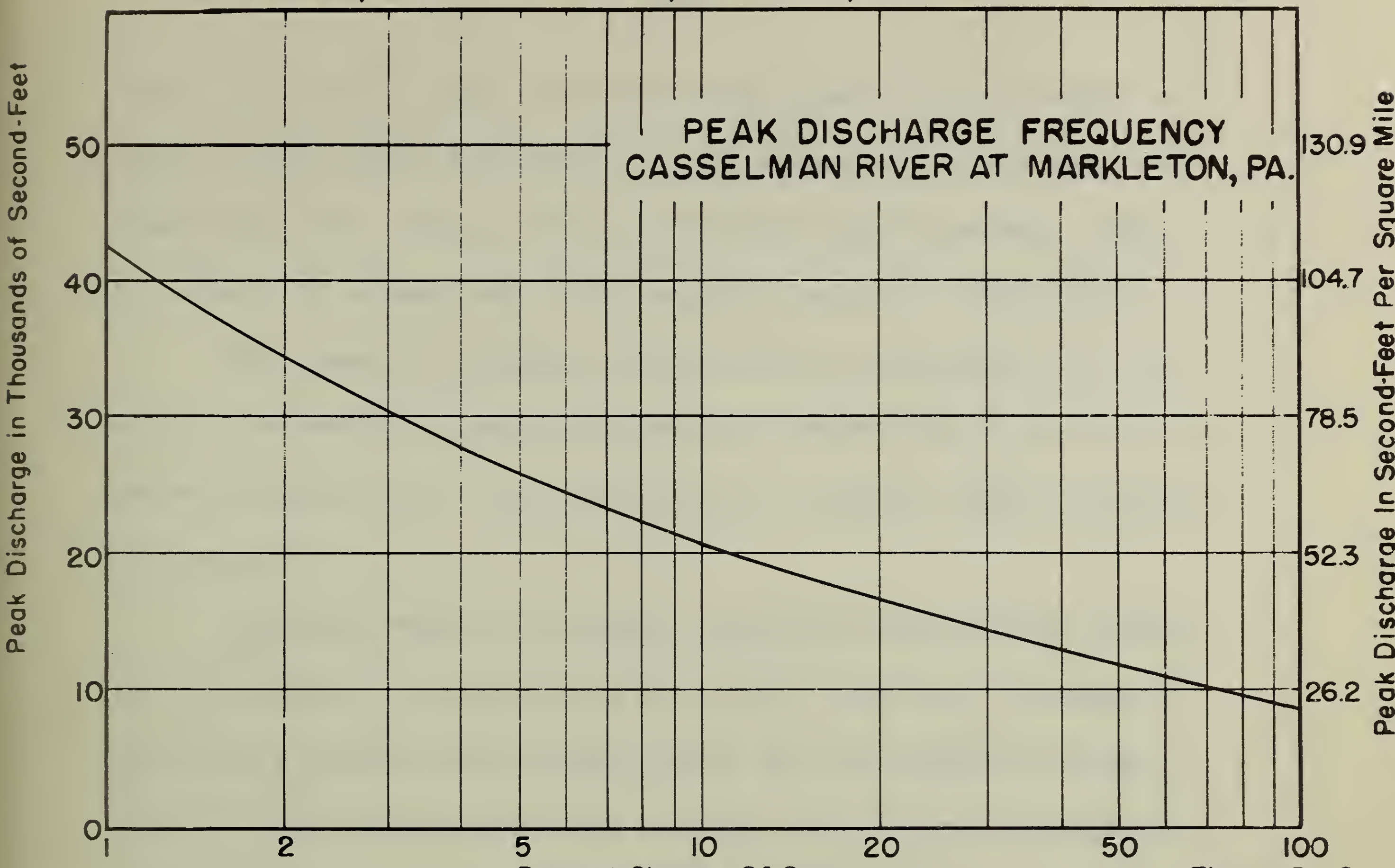

Figure D - 6

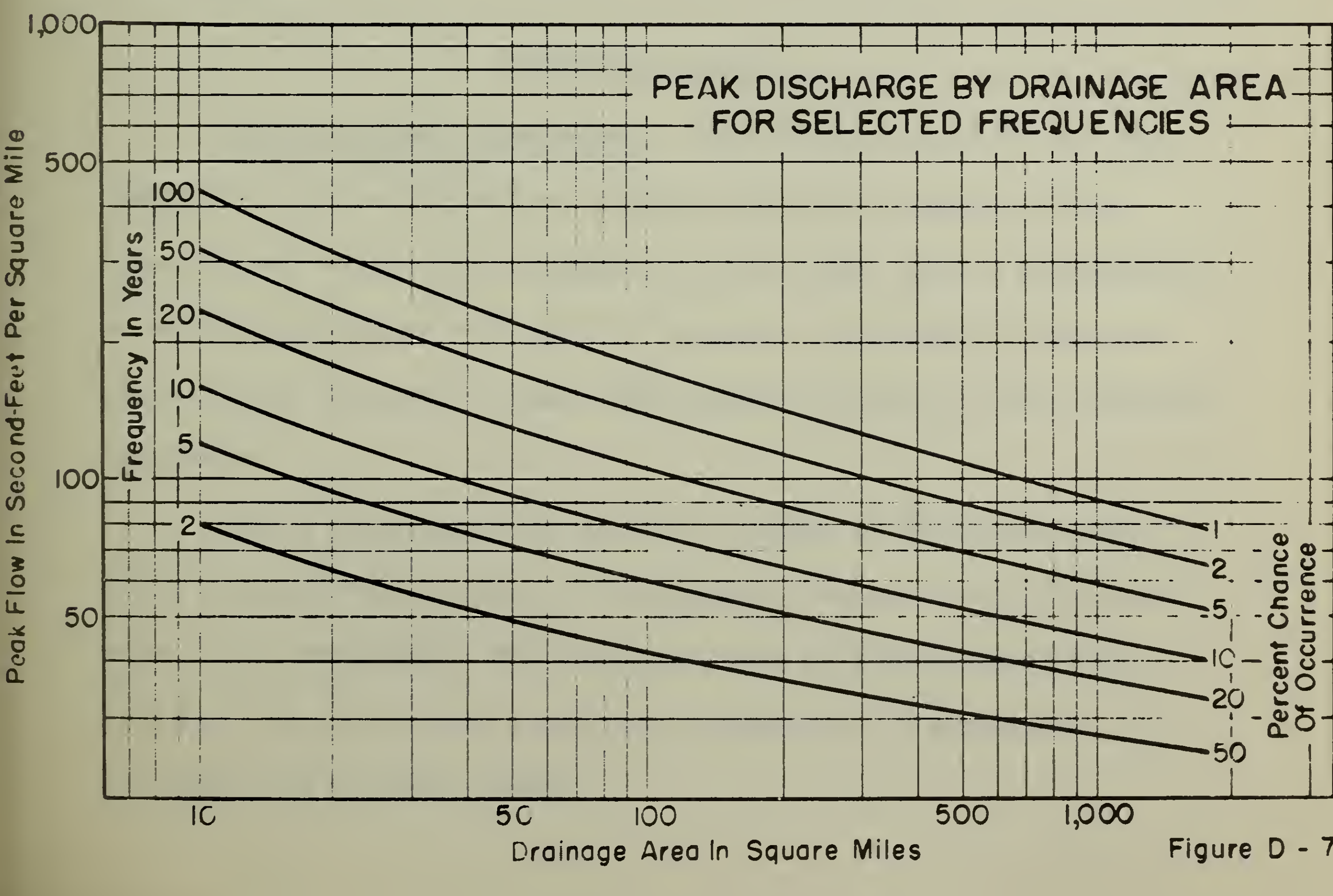

Figure D - 7

degree of erosion control attained will depend on such factors as type of soil, kind of agriculture, and nature of topography. For some fields the erosion rate can be reduced by 95 percent, while for others 60 percent may be the maximum reduction attainable.

The amount of sediment produced will be decreased as a result of retirement of steep cropland to forest land or pasture, improved rotations, and the installation of erosion control practices and measures.

Sediment damage to highways resulting from openland erosion will be subject to an estimated 70 percent reduction. Sources of such damage material are usually local and the remedy for a particular damage point frequently involves but one or, at the most, a few farms.

Additional Measures

Stream Channel Improvement - This measure provides for the excavation and realignment of stream channels to increase their capacity and reduce the frequency of out-of-bank flow. All channels on which improvement work will be done are calculated to carry an annual flood flow and to reduce the stage of floods of less frequent occurrence.

Laurel Hill Creek was used as a sample in determining the costs and benefits as well as the quantity needed of this type of work in the watershed. The estimated cost of stream channel improvement on this sample tributary is $281,346, of which $213,406 is public and $67,940 private.

Using interest rates of $2\frac{1}{2}$ and 4 percent respectively for public and private expenditures, the annual equivalent of the installation cost is $8,053. The annual maintenance and operation cost is estimated to be $7,034, which gives a total annual cost of $15,087. By using the method described in Appendix F the annual benefit resulting from the stream channel work on Laurel Hill Creek will be $22,644.

The benefit-cost ratio of this stream channel improvement work is approximately 1.5:1.

Water Retarding Structures - To determine the physical effect of the structures tentatively selected for inclusion in the recommended program (see Appendix C, Needs of the Watershed), a field study of the sites was necessary. From this study the type of structure, height, earth fill and storage capacity were estimated and, by applying unit costs, an estimate of the installation cost of the structure was made. Using the formula:

$$\left(\frac{\text{Uncontrolled Drainage Area}}{\text{Total Drainage Area}}\right)^{\frac{1}{2}} \times \text{Estimated Discharge} = \text{Modified Discharge}$$

it was possible to estimate the reduction in discharge to be expected at any damage reach below the structure. "Total Drainage Area", in the formula, is the drainage area above the damage reach, while "Uncontrolled Drainage Area" is that part of the total drainage area below the structure. "Estimated Discharge", in the formula, is the flow to be expected with recommended land treatment practices installed.

An example of the effect of this type of measure is illustrated by a particular damage point that was studied at Oakland, Maryland. A water retarding structure was planned for Cherry Glade Run, locally known as Wilson Run, a small tributary at Oakland. Total drainage area above Oakland is 2.4 square miles, while the area above the structure is 0.88 square miles. Application of the above formula gives a 14 percent reduction in peak discharge and the use of methods shown in Appendix F an annual benefit of $2,677. The estimated total installation cost of the structure amounts to $24,995, of which $22,120 is federal, $2,500 other public, and $375 private. Expressed in annual terms, using 2½ percent interest rate for public and 4 percent for private, the annual cost of the installation is $631. The annual maintenance and operation cost is estimated to be $250, making a total annual cost of $881.

The benefit-cost ratio of this structure is 3.04 to 1.

APPENDIX E

COST OF THE RECOMMENDED PROGRAM

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APPENDIX E. COST OF THE RECOMMENDED PROGRAM

Costs of the recommended program account for all expenditures required to install, maintain or operate the remedial measures. Materials and equipment supplied by the landowners or operators and unpaid family labor are included as program costs. Costs of operating farmer-owned equipment were considered as the costs involved for the additional use of the equipment. Maintenance and operation of the measures are computed in terms of annual costs.

Land Treatment Measures and Practices

Costs of specific measures were determined by applying unit costs of the measures to the number of units to be installed in the watershed. The unit costs of measures were determined by application of 1949 prices of labor, equipment and materials to the average quantity and types of labor, equipment and materials required. The costs of the individual items from which practice costs were computed are shown in table E-1. Soil Conservation Service and Forest Service records of operations were used in determining quantities and types required. Supplementary data were obtained from other Federal, state, and local agencies.

Educational costs are based on an estimate made from information supplied by the Extension Service in the states in the watershed.

The installation costs of the recommended measures include the cost of educational assistance and technical services. These costs were computed separately and then combined with costs of labor, equipment and materials for the individual measures.

Table E-1. Basic Cost Used in Computing Practice Costs
Youghiogheny River Watershed

Item	Unit	Cost Per Unit
		(dollars)
Farm Labor	Hour	0.80
Farm Tractor	Hour	0.65
Farm Truck	Hour	0.50
45 H.P. Tractor and Operator	Hour	8.50
Motorized Grader and Operator	Hour	8.10
Fertilizer (Multiflora Rose)	100#	2.50
Fertilizer (Other Practices)	100#	2.00
Lime	Ton	7.00
Ryegrass Seed	Pound	0.163
Grass Seed (Average of Several Varieties)	Pound	0.50
Fence Posts	Each	0.50
Barbed Wire	Rod	0.10
Multiflora Rose	1000 Plants	8.00
Shrubs (Wildlife Borders)	1000 Plants	8.00
Concrete (Formed)	Cu. Yd.	60.00

The total installation cost of the land treatment measures and practices is approximately $10,357,000. Of this cost the Federal Government will bear approximately 13.2 percent for technical services; 2.8 percent for administration of direct aids; 1.1 percent for educational assistance; and 28.5 percent for direct aids, special equipment and materials .... non-federal public agencies are expected to bear approximately 6.3 percent for technical services; 1.1 percent for educational assistance; and 11.8 percent for labor, materials, and equipment for installation of the land treatment program on state-owned land .... private interests are expected to bear approximately 35.2 percent for installation of the land treatment program on privately-owned land.

The installation costs of the measures and practices will be borne by the Federal Government, non-federal public agencies, and private landowners and operators, as shown in table E-2.

The Federal Government will pay one-half of the cost of technical services needed to carry out the recommended forest land program. The state and other local public agencies will pay the balance. In addition, the Federal Government will pay all of the additional cost required to stabilize and improve drainage conditions on logging roads and skid trails on private land, 77 percent of the cost of cultural operations on farm forest land, 75 percent of the cost of fencing farm woodlands against livestock, and 50 percent of the cost of planting trees. The large Federal contribution for these activities is justified since they are

Table E-2. Quantities and Distribution of Installation and Annual Operation and Maintenance Costs 1/ of the Recommended Program

Youghiogheny River Watershed

Measure	Unit	Quantity	Installation Costs				Annual Operation and Maintenance Costs			
			Federal	Non-federal		Total	Federal	Non-federal		Total
				Public 2/	Private			Public 2/	Private	
			(dollars)	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)
Land Treatment Measures										
1. Contour Strip Cropping	Acres	129,000	258,000	6,000	156,000	420,000	-	-	1,500	1,500
2. Cover Cropping	Acres	19,100	36,000	1,000	55,000	92,000	-	-	27,300	27,300
3. Diversions and Terraces	Miles	960	311,000	7,000	77,000	395,000	-	-	3,700	3,700
4. Outlets and Waterways	Acres	190	73,000	2,000	6,000	81,000	-	-	3,000	3,000
5. Establishing Perennial Hay	Acres	28,900	570,000	13,000	767,000	1,350,000	-	-	516,600	516,600
6. Pasture Management	Acres	96,500	181,000	4,000	604,000	789,000	-	-	94,300	94,300
7. Contour Furrowing	Acres	48,700	602,000	14,000	115,000	731,000	-	-	3,900	3,900
8. Streambank Erosion Control	Miles	4	38,000	1,000	16,000	55,000	-	-	2,500	2,500
9. Erosion Control Structures	Number	970	397,000	9,000	187,000	593,000	-	-	2,300	2,300
10. Improved Forest Management 3/	Acres	600,800	1,771,000	939,000	1,459,000	4,169,000	50,100	58,500	82,400	191,000
11. Tree and Shrub Planting	Acres	38,400	478,000	190,000	201,000	869,000	-	-	-	-
12. Land Acquisition	Acres	83,000	8,000	805,000	-	813,000	-	-	-	-
Sub-total I			4,723,000	1,991,000	3,643,000	10,357,000	50,100	58,500	737,500	846,100
Additional Measures										
1. Stream Channel Improvement	Miles	30	623,000	-	189,000	812,000	-	12,600	7,700	20,300
2. Water Retarding Structures	Number	7	158,000	10,000	2,000	170,000	-	1,800	-	1,800
Sub-total II			781,000	10,000	191,000	982,000	-	14,400	7,700	22,100
TOTAL			5,504,000 4/	2,001,000 5/	3,834,000	11,339,000	50,100 6/	72,900	745,200	868,200

1/ Based on 1949 prices.
2/ State and local governments, their departments and agencies.
3/ Includes necessary maintenance during installation period.
4/ Includes technical service, educational assistance, and hydrologic evaluations.
5/ Includes technical service, and educational assistance.
6/ Technical services, materials and labor.

installed primarily for the improvement of hydrologic conditions and the reasonably early benefits will be of a public nature. Private benefits in the form of cash for increased timber production will not accrue for many years.

State and other public agencies will pay all the costs of installing the above practices on all state and other public lands and will contribute about 25 percent of the cost of tree planting on private land.

Private interests will pay all the costs of cultural operations except technical services on private forest land not in farm ownership. Farmers will pay 25 percent of the cost of fencing farm forests and 25 percent of the cost of planting forest trees.

Maintenance and operation costs of the land treatment measures and practices were computed by applying unit costs of maintenance and operation to the quantities of the measures to be installed. The unit costs were developed in a manner similar to that used for installation costs. The maintenance and operation cost reflects the additional cost of farm operations.

Of the $846,100 cost of annual maintenance and operation of the land treatment measures and practices, it is expected that $737,500 or its equivalent will be expended by private landowners and operators. The Federal Government will bear $50,100 and other public agencies are expected to bear the remaining $58,500. A further breakdown of annual maintenance costs is shown in table E-2.

The total cost of public acquisition of approximately 83,000 acres of land, based on an estimated average cost of $9.80 per acre is $813,400. The cost of installing and maintaining woodland improvement and management measures on this land is included in table E-2.

It is expected that federal and non-federal public interests will bear the cost of acquisition, and the cost of necessary improvement and management measures.

Additional Measures

Stream Channel Improvement

Estimated installation costs of approximately 30 miles of stream channel improvement with the necessary lateral drainage, for prevention of damages associated with overflow and sedimentation are as follows:

Table E-3. Cost of Stream Channel Improvement
Youghiogheny River Watershed

Item	Federal Cost	Non-Federal Cost		Total Cost
		Public	Private	
	(dollars)	(dollars)	(dollars)	(dollars)
Construction Costs	502,000	-	153,000	655,000
Easements and Rights-of-Way, etc.	-	-	18,000	18,000
Engineering, Supervision, etc.	68,000	-	-	68,000
Contingency	53,000	-	18,000	71,000
TOTAL	623,000		189,000	812,000

The estimated average annual maintenance and operation cost of this measure is $20,300. It is expected that this will be borne by local interests and will be administered by a local agency or agencies acceptable to the Secretary of Agriculture. Included in the maintenance costs is the cost of the necessary inspections. The life expectancy of the features has been calculated, and an amount is included for the reconstruction of individual items as they will become inadequate.

Water Retarding Structures

Estimated installation costs of 7 water retarding structures are as follows:

Table E-4. Cost of Water Retarding Structures
Youghiogheny River Watershed

Item	Federal Cost	Non-Federal Cost		Total Cost
		Public	Private	
	(dollars)	(dollars)	(dollars)	(dollars)
Construction Costs	124,000	-	-	124,000
Easements and Rights-of-Way, etc.	-	10,000	2,000	12,000
Engineering, Supervision, etc.	14,000	-	-	14,000
Contingency	20,000	-	-	20,000
TOTAL	158,000	10,000	2,000	170,000

To determine maintenance costs on the small structures, it was estimated that the probable chance of failure would be 1 percent in any one year (design frequency 100 years); therefore, 1 percent of the construction cost is included in the annual maintenance cost

for this item. In addition, normal maintenance costs have been included for such items as mowing, site maintenance, and minor repairs. The average annual maintenance cost is estimated to be $1,800. It is expected that state or local governments will bear all of this annual maintenance. It is also expected that the total amount will be administered by a local agency or agencies acceptable to the Secretary of Agriculture.

APPENDIX F

BENEFITS OF THE RECOMMENDED PROGRAM

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APPENDIX F. BENEFITS OF THE RECOMMENDED PROGRAM

The primary effects of the recommended program toward reducing flood damage, sediment damage, and erosion damage were evaluated separately in monetary terms. Other benefits, monetarily evaluated, were increases in income and decreases in cost to landowners and operators due to the recommended changes in land management.

It is expected that the recommended program when fully effective, will reduce present flood damages approximately 28 percent within the watershed and 5 percent below the watershed. Present sediment damages will be reduced approximately 55 percent. Other benefits due to decreasing the hazards of floods and sedimentation, but not expressed in monetary terms, are savings in lives and mental distress, increase in property values, decrease in loss of fish and wildlife, increased low waterflow of streams resulting in pollution abatement, fewer interruptions in community functions, and others of more or less intangible nature.

Changes in land use and management, as recommended, will increase cropland and forest land production. They will also substantially control erosion which, in turn, will maintain present rates of production and/or decrease costs of production. These benefits, to the extent that they accrue to the landowners and operators, have been evaluated in monetary terms. From these private benefits, however, the public will gain by way of maintenance of natural resources and public revenues, a constant supply of crop and forest land products, improved recreational facilities, and increases in wildlife throughout the watershed.

The computation of benefits to be derived from the recommended openland treatment measures are based upon total needs of the watershed, which includes the estimated quantities of measures to be installed through going programs. Benefits of the total watershed needs of openland measures were evaluated and a portion of this benefit was allocated to the "recommended" measures. This procedure was used because of the difficulty in separating the effects of the "going" and "recommended" programs on land use adjustments.

Benefits of the recommended forest land measures were computed directly since the effects of the recommended program on runoff and forest land production could be calculated separately from the similar effects of the "going" program.

Reduction in Flood Damage

Benefits resulting from reductions in flood damages were derived separately for each stream where damages were evaluated. A summary of average annual flood damages and flood benefits is shown in table F-1. The benefit is equivalent to the difference in average annual damage sustained under present watershed conditions and the average annual damages to be expected with conditions prevailing under the recommended program. The benefits of the recommended land treatment measures and of the "additional measures" were computed separately. Benefits of the latter group were computed as the additional reduction in flood damages after applying the land treatment measures. The evaluated damages

Table F-1. Average Annual Flood Damages and Flood Damage Reductions due to the Recommended Program
Youghiogheny River Watershed
(1949 Prices)

	Average Annual Damage With			Damage Reduction From		
	Present Conditions	Total Land Treatment	Additional Measures 1/	Recommended Land Treatment	Additional Measures 2/	Total
	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)
Within Watershed						
Main Stem Youghiogheny	20,400	15,100	15,100	4,900	-	4,900
Casselman River	9,500	6,900	6,900	2,400	-	2,400
Laurel Hill Creek	6,900	6,200	6,200	700	-	700
Indian Creek	11,400	9,400	9,400	1,900	-	1,900
Jacobs Creek	13,100	10,700	10,700	2,200	-	2,200
Sewickley Creek	15,200	12,700	12,700	2,300	-	2,300
Miscel. Tributaries	64,100	50,700	37,900	12,500	12,800	25,300
Subtotal	140,600	111,700	98,900	26,900	12,800	39,700
Below Watershed						
McKeesport	40,000	38,000	38,000	1,900	-	1,900
Pittsburgh	1,186,500	1,115,500	1,115,500	66,000	-	66,000
Wheeling	451,500	433,200	433,200	17,000	-	17,000
Subtotal	1,678,000	1,586,700	1,586,700	84,900	-	84,900
TOTAL	1,818,600	1,698,400	1,685,600	111,800	12,800	124,600

1/ The damage values account for effect of additional measures in combination with total land treatment.

2/ These values include only the incremental reductions effected by additional measures.

shown do not include those which are expected to be controlled by existing projects or projects under construction by the Department of the Army, Corps of Engineers. The methods used for deriving flood damage reductions differed slightly among tributaries of the Youghiogheny River, main stem of the Youghiogheny River, and below the watershed. The methods are indicated as follows:

Casselman River - Damage frequency relations, representing present watershed conditions and conditions with the total land treatment program, are shown by two graphs in figure F-1. The upper graph shows the damage frequency relations representing present watershed conditions, while the graph immediately below it shows this relationship for conditions prevailing with total land treatment. These graphs, indicating damage-frequency relations, were developed by means of substituting flood damage for discharge in the graphs of discharge-frequency relations, shown in figure F-2. The method of deriving the latter graphs is illustrated in Appendix D.

The benefits are computed from the graphs in figure F-1. The present average annual damages are $9,500 and with the land treatment measures $6,900. Hence, the benefit of the total land treatment measures is $2,600.

The amount of this total benefit attributable to the recommended program was estimated by a consideration of the watershed requirements of runoff control practices, their relative effectiveness, and the quantities of such practices included in the

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SOIL CONSERVATION SERVICE
H. H. BENNETT, CHIEF

YOUGHIOGHENY RIVER WATERSHED
PENNSYLVANIA-MARYLAND-WEST VIRGINIA

NORTHEAST REGION I
AUSTIN L. PATRICK
REGIONAL DIRECTOR

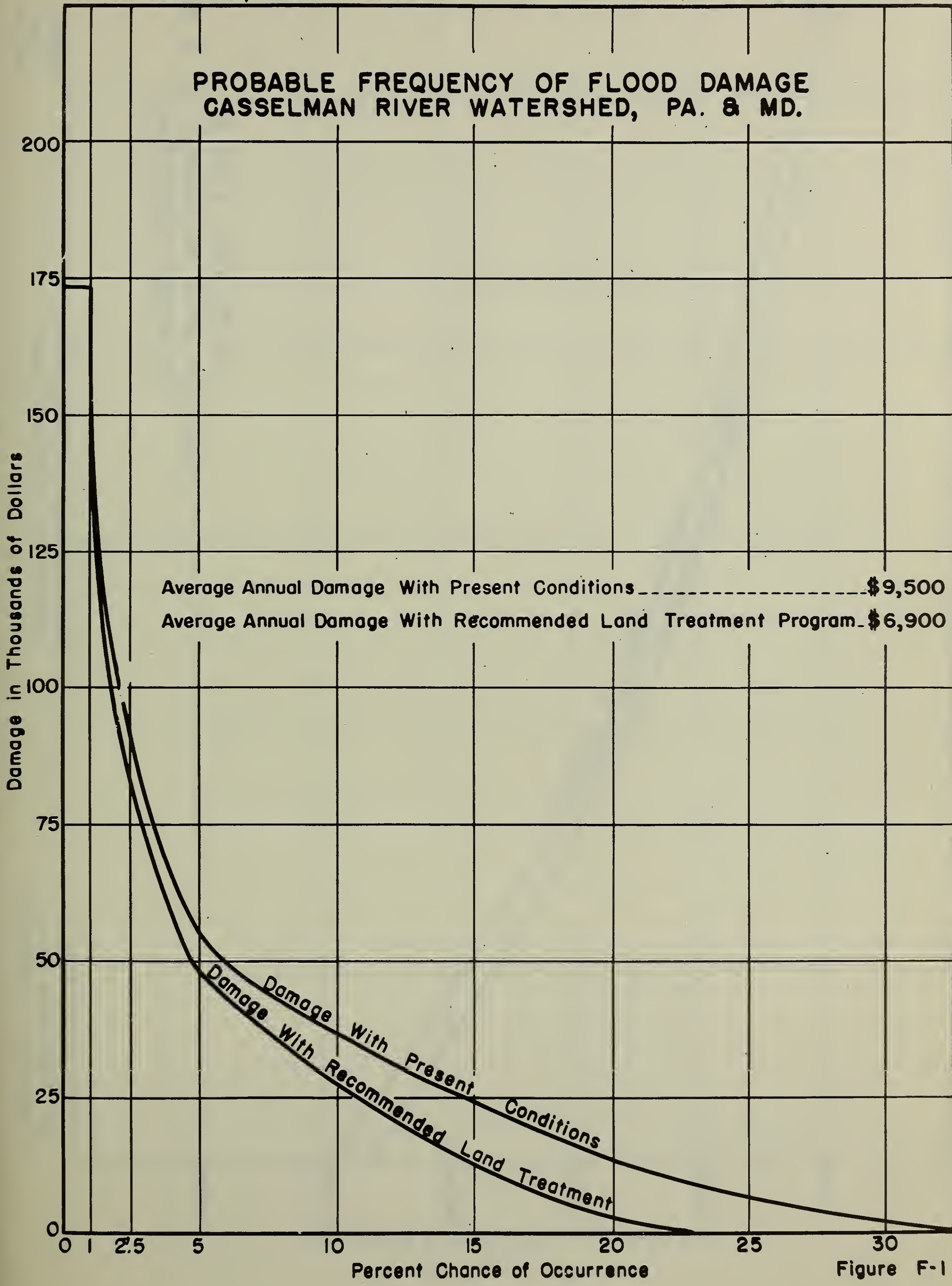

Figure F-1

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
H.H. BENNETT CHIEF

YOUGHIOGHENY RIVER WATERSHED
PENNSYLVANIA, MARYLAND, WEST VIRGINIA

NORTHEAST REGION I
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REGIONAL DIRECTOR

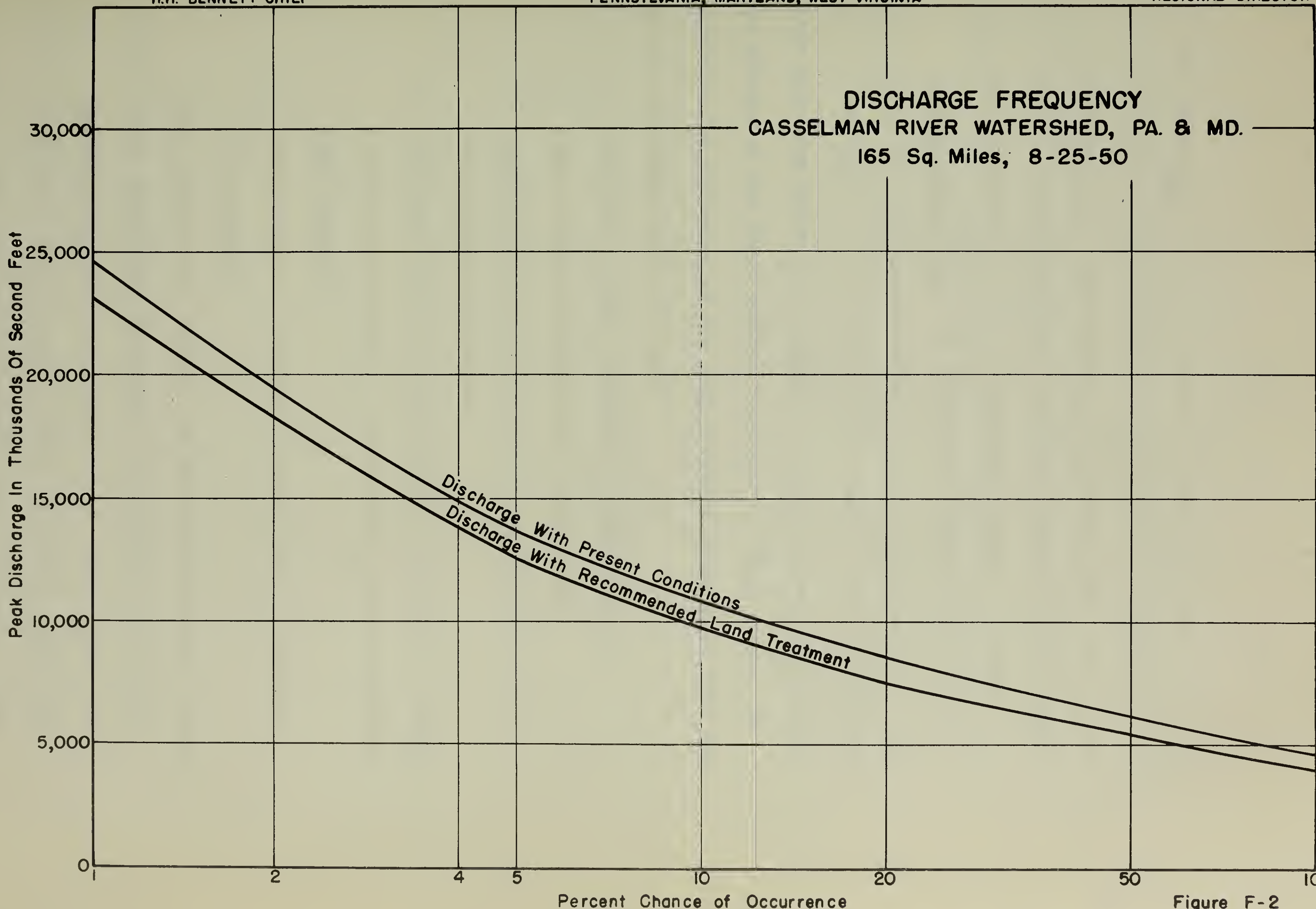

Figure F-2

recommended program. It was estimated that 80 percent of the flood control benefit of the openland measures should be credited to the recommended program. Approximately 35 percent of the total benefit is due to openland measures. Thus the amount of flood damage reductions attributable to the recommended program is $2,400.

Youghiogheny River - No significant damage occurs on the main stem of the Youghiogheny River above the flood control reservoir at Confluence. The average annual damage on the Youghiogheny River main stem below the reservoir is $20,400 after considering the effects of the flood control reservoir on flood stage. To determine the influence of the land treatment program on this damage, the following data were used:

1. Discharge - stage relations at Connellsville.
2. Stage - damage relations at Connellsville.
3. Stages of flood occurrences at Connellsville between 1895 and 1946 inclusive.
4. Calculated effect of flood control reservoir on stages of flood occurrences at Connellsville between 1895 and 1946 inclusive.
5. Flood stage at Connellsville modified by land treatment measures.

Flood damages were computed for the modified stages and the average annual damage was calculated. The effect of the total land treatment program was to reduce average annual damage from $20,400 to $15,100, or an annual benefit of $5,300. Using the procedure as indicated for the Casselman River, $4,900 of this benefit is attributable to the recommended program.

F

Damage Zones Below the Watershed Affected by Discharge from the Youghiogheny River - Downstream benefits, resulting from the recommended program in the watershed, were determined within the Department of the Army, Corps of Engineers damage districts of McKeesport, Pennsylvania, Pittsburgh, Pennsylvania, and Wheeling, West Virginia. The effect of the Youghiogheny River flood control reservoir on peak discharge of the March 1936 flood, had it been constructed, as developed from data furnished by the Corps of Engineers indicates that the peak discharge of the March 1936 flood at Sutersville, Pennsylvania, on the Youghiogheny River near its mouth would have been reduced by 21,380 cubic feet per second, at Pittsburgh 16,200 cubic feet per second, and at Wheeling 11,950 cubic feet per second.

By use of methods explained in appendix D it was determined that the land treatment program, had it been installed, would have reduced the peak discharge of the March 1936 flood at Sutersville by 7,100 cubic feet per second. This reduction at Sutersville is equivalent to 33.2 percent of that afforded by the flood control reservoir. Thus the land treatment program would have reduced the peak discharge of the March 1936 flood at Pittsburgh by 33.2 percent of 16,200, or 5,378 cubic feet per second, and similarly 3,967 cubic feet per second at Wheeling.

Other information obtained from Department of the Army, Corps of Engineers, indicates the following:

1. Effect of constructed flood control reservoirs and those under construction on peak flood stages at Pittsburgh and Wheeling.

2. Relation of stage to discharge at Pittsburgh and Wheeling.

3. Stage-damage relationships at McKeesport, Pittsburgh, and Wheeling.

By use of the above data, the reductions in peak discharge of the March 1936 flood at Pittsburgh and Wheeling, afforded by the land treatment program, were converted to stage reductions at the flood stage prevailing after the effectiveness of the reservoir program is considered. The effects of the recommended program on varying flood stages were computed in conformity with the relationships developed by the Corps of Engineers.

Flood benefits in the respective damage districts were computed as the difference in average annual damages prevailing under conditions with the Corps of Engineers reservoir program, and average annual damages existing after the land treatment program becomes effective. Benefits in the McKeesport district were computed based on stages at Pittsburgh, inasmuch as the damages in the McKeesport district were related to stage at Pittsburgh.

Land Enhancement

In many low gradient streams, where frequent flooding and sedimentation occurs, the bottomland is used less intensively than its capability would otherwise permit. The flood damage in these areas is relatively low because of the present limited use of the land. However, benefits would be considerable if the frequent

flooding and sedimentation were prevented. This situation is most extensive in the upper reaches of Coxes and Laurel Hill Creeks. Extent of damage, methods of control, costs, and benefits were studied in these areas. Benefits due to the enhancement of the agricultural land by way of channel improvement, prevention of frequent inundation, and reduction of sedimentation were determined as the difference in the net value of crop and pasture production under present conditions, and under conditions prevailing with the corrective measures installed. Based on the investigations made on Coxes and Laurel Hill Creeks, the estimated annual land enhancement benefit in the Youghiogheny River Watershed is $64,200 on approximately 3,800 acres.

The method used in computing the annual value of land enhancement is illustrated by the data presented in table F-2, Costs of crop production were estimated to include such items as seed, fertilizer, land preparation, cultivation, harvest, and all labor. Costs of land clearing, farm ditching, etc., were included as project costs. No reductions in flood damage to growing crops in this area were claimed. In estimating crop yields for both present and future conditions, the probable extent of flood damage was considered.

Reduction in Sediment Damage

Reduction of Maintenance Costs of Highways - The land treatment measures will substantially reduce highway maintenance costs caused by sedimentation. Of the $47,800 annual damage to highways

Table F-2. Annual Value of Land Enhancement
Laurel Hill Creek Watershed
Youghiogheny River Watershed
(1949 Prices)

Land Use	Acres	Yield	Value of Production Per Unit	Value of Production Per Acre	Cost of Crop Production Per Acre	Net Value of Production Per Acre	Net Value of Production Total Acres
			(dollars)		(dollars)	(dollars)	
PRESENT							
Corn	100	50 Bu.	1.44	72.00	40.00	32.00	3,200
Oats	100	40 Bu.	.76	30.40	29.00	1.40	140
Hay	100	2 Ton	24.48	48.96	30.00	18.96	1,896
Permanent Pasture	1,000	$8.00	8.00	8.00	2.00	6.00	6,000
TOTAL	1,300						11,236
FUTURE							
Corn	340	62 Bu.	1.44	89.28	44.00	45.28	15,395
Oats	170	50 Bu.	.76	38.00	30.00	8.00	1,360
Hay	340	2.5 Ton	24.48	61.20	32.00	29.20	9,928
Permanent Pasture	220	$18.00	18.00	18.00	8.60	9.40	2,068
Hay-Pasture	230	$42.60	42.60	42.60	20.30	22.30	5,129
TOTAL	1,300						33,880
Net Increase							22,644

it is estimated that 70 percent or $33,500 will be prevented, due to the soil stabilizing effect of the total land treatment program. Of this benefit, approximately 80 percent or $26,800 is attributable to the recommended program.

Reduction of Dredging Costs - Due to the effect of the total land treatment measures, it is expected that deposition in the navigable channel of the Youghiogheny River will be reduced 3,000 cubic yards annually. This reduction is equivalent to a benefit of $3,750, of which 80 percent or $3,000 is attributable to the recommended land treatment measures.

Conservation Benefits

Benefits of the recommended program other than flood and sediment reductions accrue as a result of the following changes:

1. Decrease in rate of soil erosion.
2. Increased production of crops, forage and forest land products,
3. Savings in crop production costs.

These benefits are a result of the conservation practices and measures recommended for the attainment of reductions in flood and sediment damages.

Decrease in Rate of Soil Erosion

Based on results of soil erosion research, it is expected that the combined effect of the "going" and recommended conservation measures will reduce the annual soil erosion rate on cropland by 75 percent. Applying this percent reduction directly to the

erosion damages shown in Appendix B, the annual equivalent benefit is approximately $455,900. The amount of this benefit attributable to the recommended program was estimated by a consideration of the watershed requirements of erosion control practices, their relative effectiveness, and the quantities of such practices included in the recommended program. A listing of the watershed needs for land treatment measures and practices and the recommended quantities are shown in Appendix C. Contour strip cropping, diversions and terraces, perennial hay, and cover cropping are some of the most effective erosion controlling measures. It was estimated that approximately 80 percent of the erosion control benefit, or $364,700, should be credited to the recommended program.

Increased Production of Crops, Pasture and Forest Products

Crops - Increased yields, due to improved land use, and application of conservation practices were estimated at 10 percent for row and close growing crops, and 22 percent for hay. The relatively larger increase in hay yield is due to the addition of perennial hay in the cropping system. This crop, in order to be effective in controlling erosion and retarding runoff, must be adequately maintained by the application of fertilizer. For rotation crops no changes in seed varieties or fertilizer practices were recommended. Retirement of the steeper and more erodible cropland, and the application of contour strip cropping and cover cropping along with installation of adequate water disposal systems will furnish adequate erosion and runoff control. Therefore, the estimated yield increases of rotation crops account for only the

moisture conservation effect of the measures and the retirement of the lower yielding croplands.

Benefits from the increased production of crops due to the influence of the "going" and recommended programs are shown in table F-3. From an analysis of the two programs it was estimated that approximately 80 percent, or $622,700, of the benefit is attributable to the recommended program.

<u>Pasture</u> - Management of pasture is recommended for 96,500 acres. The measure "pasture management", as described in Appendix C, includes mowing to control weeds and remove mature grasses, scattering of droppings, and regulating the intensity of grazing. The benefit from this measure was based on the estimated grazing capacity being increased from 2.0 acres per grazing unit to 1.7 acres per grazing unit. This increase is equivalent to a 17.6 percent greater grazing capacity. It was estimated that the yield of one acre of pasture without "management" was equivalent to 1.5 tons of hay. Valued at $24.48 per ton this hay equivalent is worth $36.72. The grazing value, however, was assumed to be 50 percent of the hay value, or $18.36 per acre. The 17.6 percent increase in yield amounts to $3.23 per acre, or approximately $311,700 for the 96,500 acres recommended to receive management.

The attainment of the pasture benefit appears feasible in view of present farm management trends in the watershed. Based on accomplishments to date, it is expected that "going programs" within the 20-year installation period will establish the required amount

Table F-3. Value of Crop Production Under Present Conditions and with Land Treatment Program
Youghiogheny River Watershed
(1949 Prices)

	Acres	Yield Unit	Yield Amount	Production	Value Per Unit	Total Value
				(units)	(dollars)	(dollars)
			Present			
Corn Grain	38,231	Bu.	39.60	1,513,948	1.44	2,180,085
Corn Silage	15,602	Ton	10.00	156,020	9.80	1,528,996
Wheat	25,361	Bu.	20.50	519,901	1.80	935,822
Oats	56,547	Bu.	32.50	1,837,778	.76	1,396,711
Hay	113,374	Ton	1.24	140,584	24.48	3,441,495
Potatoes	3,630	Bu.	180.00	653,400	1.55	1,012,770
TOTAL	252,745					10,495,880
			With Land Treatment			
Corn Grain	32,324	Bu.	43.6	1,409,326	1.44	2,029,429
Corn Silage	13,993	Ton	11.0	153,923	9.80	1,508,445
Wheat	21,420	Bu.	22.5	481,950	1.80	867,510
Oats	47,843	Bu.	35.7	1,707,995	.76	1,298,076
Hay	120,569	Ton	1.51	182,059	24.48	4,456,804
Potatoes	3,630	Bu.	198.0	718,740	1.55	1,114,047
TOTAL	239,779					11,274,311
Net Increase in Value of Production						778,431

of pasture improvement by seeding, fertilizing, and liming. There were approximately 54,000 grazing units in the watershed in 1945, as indicated by the U. S. Census. From 1935 to 1945, the average annual increase amounted to about 1,000. If this trend continues, a greater production of pasture will be required.

Forest Land - Economic returns to forest land owners will be increased through the installation of the recommended program. Application of improved forest management practices on the area recommended for treatment will increase the estimated present average annual yield of 25 cubic feet per acre to an estimated average yield of 60 cubic feet per acre or approximately 240 percent.

Evaluation of these benefits consisted of determining the difference in value between yield of average present forest land and yield that could be expected under the conditions of the recommended program. These values were determined by the application of present average stumpage prices, weighted by present and estimated future production of various products. Growth rates, commodity drain, and price estimates were based largely on studies of the Northeastern Forest Experiment Station. Present and future estimated distribution of various products and their values are shown in table F-4.

On this basis the value of the present average annual yield of 25 cubic feet per acre is $1.16. The value of the estimated future annual yield of 60 cubic feet is $3.11. The increase in

value is somewhat greater than the increase in cubic volume because a larger percent of higher value products will be produced from the well managed forest of the future. An example of this is the increase in percent of lumber and veneer materials.

Table F-4. Derivation of Stumpage Values Per Cubic Foot of Forest Land Growth Under Conditions Without and With the Recommended Program
Youghiogheny River Watershed

Products	Unit	Value Per Unit	Without Recommended Program			With Recommended Program	
			Value Per Cubic Foot	Proportion of Production	Proportionate Value	Proportion of Production	Proportionate Value
		(dol.)	(dol.)	(%)	(dol.)	(%)	(dol.)
Lumber	MBF	12.00	.060	26	.0156	40	.0240
Pulpwood	Cord	2.00	.031	30	.0093	25	.0078
Mine Timbers	Cord	3.50	.044	37	.0163	20	.0088
Veneer	MBF	20.00	.100	2	.0020	5	.0050
Other	Cord	5.00	.062	5	.0031	10	.0062
Average					.0463		.0518

Estimates of future values are conservative because no account was taken of the increase in stumpage prices that should result from increased high quality material, and better utilization and market outlets. The future annual harvest of products without a program was estimated to be equal to present conditions.

Returns were computed only for those areas devoted to timber production. Approximately 14,400 acres of non-commercial forest area, including parks and game lands managed primarily for purposes other than wood production were excluded from all benefit computations. The net area available for timber production under present conditions is 574,300 acres. It is estimated that current programs will bring about 56,500 acres under management. Accordingly, future income without the recommended program installed was computed on the basis of 56,500 acres producing an annual income of $3.11 per acre and 517,800 acres producing an annual income of $1.16 per acre. The expected future annual returns are $776,400.

The future gross area of forest land to be managed for forest products is 600,800 acres. 1/ Annual returns from this area, with the recommended program fully effective, are $3.11 per acre. The total returns are $1,868,500.

The benefit attributable to the recommended program is the difference between the returns from the total future forest land area and the returns that would result from the present area with only current programs in effect. This benefit amounts to $1,092,100.

Savings in Crop Production Costs - It is estimated that the installation of the required land treatment measures and practices will effect net decreases in row crops and close growing crops of 7,516 acres and 12,645 acres respectively and a net increase of 7,195 acres of hay crops. The annual savings in production costs, due to the adjustments in acreage of row crops and close growing

1/ It is estimated that 4,300 acres of the land acquired by the public will become a part of existing state and local parks and game lands.

crops, were computed at $30.00 and $22.50 per acre respectively. These estimates represent averages of the production costs prevailing on lands to be retired and on lands converted to crops. Most of the cropland to be retired is on steep slopes and subject to severe erosion, droughty or wet, low yielding and, in many cases, receives less fertilizer and cultivation than the better lands. In general, its economic capacity is low.

Changes in production costs of hay crops were based on a $12.00 per acre saving on the 29,405 acres of hayland being retired and $25.87 per acre increase on the 36,600 acres of land converted to perennial hay. Since all the production costs of perennial hay, except for harvesting, were included in the maintenance costs of the program measures (see table E-2, item 5), only the harvesting cost, or $8.00, was considered in computing savings.

The net effect of the cropland adjustments for the watershed is a decrease in production costs of approximately $570,100. This benefit, $570,100, is a result of the land use adjustments caused by the combined effect of the "going" and recommended programs. From an analysis of the two programs, it was estimated that 80 percent, or $456,100, of the benefit is attributable to the recommended program.

Summary of Monetary Benefits

The evaluated monetary benefits attributable to the recommended program, when it attains maximum effectiveness, are summarized in table F-5. It is estimated that openland measures will

reach maximum effectiveness within five years after installation. The forest land measures are expected to reach 20 percent of maximum effectiveness 15 years after installation, 87 percent at 40 years and attain full effectiveness in 70 years. The additional measures will be fully effective immediately following their installation.

Table F-5. Estimated Average Annual Monetary Benefit from the Recommended Program Youghiogheny River Watershed (1949 Prices)

Type of Benefit	Average Annual Benefit	
Reduction in damage due to inundation		
Within Watershed	39,700	
Below Watershed	84,900	
Subtotal		124,600
Reduction in damage due to sediment		
Highways	26,800	
Channel Dredging	3,000	
Subtotal		29,800
Reduction in damage due to erosion		364,700
Land Enhancement		64,200
Other Benefits		
Increased Crop Production	622,700	
Increased Pasture Production	311,700	
Increased Forest Land Production	1,092,100	
Saving on Crop Production Costs	456,100	
Subtotal		2,482,600
TOTAL		3,065,900

APPENDIX G

COMPARISON OF BENEFITS AND COSTS

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APPENDIX G. COMPARISON OF BENEFITS AND COSTS

Benefits and costs were computed separately for the land treatment program, the additional measures, and for the individual groups of measures that are included in the additional measures. All benefits and costs were appraised in terms of 1949 prices. To compare benefits and costs, all values were expressed in annual terms. In converting installation costs to annual values, $2\frac{1}{2}$ and 4 percent interest rates were used respectively for public and private expenditures. For those measures where a significant delay is expected between the time of the expenditure and the accrual of the benefit, discounting was employed using the interest rates cited above. Shown in table G-1 are the computed benefit-cost ratios based on prevailing prices in 1949 and under intermediate employment levels during the period 1955-1965. The indices used in converting benefits and costs to 1955-1965 price levels are shown in table G-2.

Land Treatment Measures and Practices

In developing the land treatment measures, the aim was to include only those measures whose benefits were in excess of costs. However, because of the interdependency of many individual measures and practices, the benefits were computed for groups of measures. The methods of deriving costs and benefits are shown in Appendixes E and F.

In computing the benefit-cost ratio, discounting was employed in evaluating benefits. In the case of woodland measures, certain

Table G-1. Annual Equivalent of Benefits and Costs of
Recommended Program by Groups of Measures
1949 Prices and Alternate Price Level
Youghiogheny River Watershed

Type of Measure	1949 Prices			1955-1965 Prices 1/		
	Annual Cost	Annual Benefit	Benefit-Cost Ratio	Annual Cost	Annual Benefit	Benefit-Cost Ratio
	(dollars)	(dollars)		(dollars)	(dollars)	
Land Treatment	1,055,613	2,179,111	2.06 - 1	693,896	1,298,587	1.87 - 1
Additional Measures:						
Channel Improvement	43,435	64,200	1.48 - 1	29,135	38,674	1.33 - 1
Water Retarding Structures	6,080	12,800	2.11 - 1	4,142	8,720	3.11 - 1
Subtotal	49,515	77,000	1.56 - 1	33,277	47,394	1.42 - 1
ALL MEASURES	1,105,128	2,256,111	2.04 - 1	727,173	1,345,981	1.85 - 1

1/ Prices expected to prevail under intermediate employment levels in the period 1955-1965.

Table G-2. Indices Used in Converting Costs and Benefits to Price and Cost Levels of 1955-1965 1/
Youghiogheny River Watershed

Name of Index	Index Number 1949	Index Number 1955-1965	Item of Cost or Benefit
Prices received by farmers 2/	249	150	Land enhancement
			Reduction in erosion damage
			Increased crop production
			Increased pasture production
Prices paid by farmers 2/	238	155	Savings in production costs
			Private costs of channel improvement
			Private costs of land treatment
Wholesale lumber prices 3/	286	145	Increased woodland production
Construction cost 4/	477	325	Reduction of flood damages by land treatment and water retarding structures
			Reduction in sediment damage
			All other costs

1/ Under condition of intermediate employment.

2/ Bureau of Agricultural Economics.

3/ U. S. Department of Labor.

4/ Engineering News-Record.

of the maintenance costs will occur in proportion to the incidence of benefits; therefore, they were also discounted. The cumulative maintenance costs of woodland measures to be incurred during the 20-year period of installation, included in table E-2, were not used in computing the benefit-cost ratios. These costs totaled $1,883,000, of which $555,000 is federal, $524,000 other public, and $804,000 private. Since, for purposes of calculating benefit-cost comparisons, the annual maintenance costs were considered to start immediately after installing the measure, it was not necessary to include the cumulative maintenance costs during the 20-year period required to install the entire program.

The land treatment costs and benefits were discounted, where necessary, and reduced to annual equivalents as follows:

Costs

Openland (discounting not necessary)

Installation		Annual Equivalent
Federal	$2,466,000	$ 61,650
Other Public	57,000	1,425
Private	1,983,000	79,320
Maintenance		
Private	655,100	655,100
Total Openland Costs		$797,495

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Forest Land		Annual Equivalent
Installation (discounting not necessary)		
Federal	$1,702,000	$ 42,550
Other Public	1,410,000	35,250
Private	856,000	34,240
Maintenance (other than timber marking)		
Federal	$ 15,000	$ 15,000
Other Public	10,800	10,800
Private	68,900	68,900
Maintenance (timber marking, discounted)		
Public (maximum annual, $82,800)		
A. Full annual cost 70 years hence: $82,800 x .17755		14,701
B. 87% of full cost 40 years hence for a period of 30 years: $72,036 x .19488 1/		14,038
C. Annual cumulative cost of $\frac{13\% \times 82{,}800}{30}$ 40 years hence for a period of 30 years: $359 x 2.66335 2/		956
D. 20% of full cost 15 years hence for a period of 25 years: $16,560 x .31804 3/		5,267
E. Annual cumulative cost of $\frac{(\$72{,}036 - \$16{,}560)}{25}$ 15 years hence for a period of 25 years: $2,219 x 3.72869 4/		8,274
F. Annual cumulative cost of $\frac{20\% \times \$82{,}800}{15}$ for 15 years: $1,104 x 2.33393 5/		2,577

1/ Discount factor, 20.93029 x .37243 x .025 = .19488
2/ Discount factor, 286.05078 x .37243 x .025 = 2.66335
3/ Discount factor, 18.42438 x .69047 x .025 = .31804
4/ Discount factor, 216.00885 x .69047 x .025 = 3.72869
5/ Discount factor, 93.35715 x .025 = 2.33393

	Annual Equivalent
Private (maximum annual, $13,500)	
A. Full annual cost 70 years hence: $13,500 x .06422	$ 867
B. 87% of full cost 40 years hence for a period of 30 years: $11,745 x .14407 1/	1,692
C. Annual cumulative cost of $\frac{13\% \times 13{,}500}{30}$ 40 years hence for a period of 30 years: $58.50 x 1.81924 2/	106
D. 20% of full cost 15 years hence for a period of 25 years: $2,700 x .34697 3/	937
E. Annual cumulative cost of $\frac{(\$11{,}745 - \$2{,}700)}{25}$ 15 years hence for a period of 25 years: $362 x 3.81410 4/	1,381
F. Annual cumulative cost of $\frac{20\% \times 13{,}500}{15}$ for 15 years: $180 x 3.23416 5/	582
Total Forest Land Costs:	$258,118
Total Land Treatment Costs:	$1,055,613

1/ Discount factor, 17.29203 x .20829 x .04 = .14407

2/ Discount factor, 218.35386 x .20829 x .04 =1.81924

3/ Discount factor, 15.62208 x .55526 x .04 = .34697

4/ Discount factor, 171.72608 x .55526 x .04 =3.81410

5/ Discount factor, 80.85389 x .04 =3.23416

Benefits

Reduction in Flood Damage Due to Forest Land Treatment
(Maximum Annual $78,100)

	Annual Equivalent
A. Full annual benefit 70 years hence: $78,100 x .17755	$13,867
B. 87% of full benefit 40 years hence for a period of 30 years: $67,947 x .19488 1/	$13,242
C. Annual cumulative benefit of $\frac{13\% \times \$78,100}{30}$ 40 years hence for a period of 30 years: $338 x 2.66335 2/	900
D. 20% of full benefit 15 years hence for a period of 25 years: $15,620 x .31804 3/	4,968
E. Annual cumulative benefit of $\frac{(67,947 - 15,620)}{25}$ 15 years hence for a period of 25 years: $2,093 x 3.72869 4/	7,804
F. Annual cumulative benefit of $\frac{20\% \times \$78,100}{15}$ for 15 years: $1,041 x 2.33393 5/	2,430
TOTAL	$43,211

Reduction in Flood Damage Due to Openland Treatment
(Maximum Annual $33,700)

A. Full annual benefit 5 years hence: $33,700 x .88385	$29,786
B. Annual cumulative benefit of $\frac{33,700}{5}$ for 5 years: $6,740 x .34270 6/	2,310
TOTAL	$32,096

1/ Discount factor, 20.93029 x .37243 x .025 = .19488
2/ Discount factor, 286.05078 x .37243 x .025 = 2.66335
3/ Discount factor, 18.42438 x .69047 x .025 = .31804
4/ Discount factor, 216.00885 x .69047 x .025 = 3.72869
5/ Discount factor, 93.35715 x .025 = 2.33393
6/ Discount factor, 13.70811 x .025 = .34270

Reduction in Damage Due to Erosion
(Maximum Annual $364,700)

	Annual Equivalent
A. Full annual benefit 5 years hence: $364,700 x .82193	$299,758
B. Annual cumulative benefit of 364,700/5 for 5 years: $72,940 x .52026 1/	37,948
TOTAL	$337,706

Reduction in Sediment Damage to Highways
(Maximum Annual $26,800)

A. Full annual benefit 5 years hence: $26,800 x .88385	$ 23,687
B. Annual cumulative benefit of 26,800/5 for 5 years: $5,360 x .34270 2/	1,837
TOTAL	$ 25,524

Reduction in Channel Dredging Costs
(Maximum Annual $3,000)

A. Full annual benefit 5 years hence: $3,000 x .88385	$ 2,652
B. Annual cumulative benefit of 3,000/5 for 5 years: $600 x .34270 2/	206
TOTAL	$ 2,858

1/ Discount factor, 13.00649 x .04 = .52026

2/ Discount factor, 13.70811 x .025 = .34270

Increased Forest Land Production
(Maximum Annual $1,092,100)

	Annual Equivalent
A. Full annual benefit 70 years hence: $1,092,100 x .06422	$ 70,135
B. 87% of full benefit 40 years hence for a period of 30 years: $950,127 x .14407 1/	136,885
C. Annual cumulative benefit of $\frac{13\% \times \$1,092,100}{30}$ 40 years hence for a period of 30 years: $4,732 x 1.81924 2/	8,609
D. 20% of full benefit 15 years hence for a period of 25 years: $218,420 x .34697 3/	75,785
E. Annual cumulative benefit of $\frac{(\$950,127 - \$218,420)}{25}$ 15 years hence for a period of 25 years: $29,268 x 3.81410 4/	111,631
F. Annual cumulative benefit of $\frac{20\% \times \$1,092,100}{15}$ for 15 years: $14,561 x 3.23416 5/	47,093
TOTAL	$450,138

Increased Crop Production
(Maximum Annual $622,700)

A. Full annual benefit 5 years hence: $622,700 x .82193	$511,816
B. Annual cumulative benefit of $\frac{622,700}{5}$ for 5 years: $124,540 x .52026 6/	64,793
TOTAL	$576,609

1/ Discount factor, 17.29203 x .20829 x .04 = .14407
2/ Discount factor, 218.35386 x .20829 x .04 = 1.81924
3/ Discount factor, 15.62208 x .55526 x .04 = .34697
4/ Discount factor, 171.72608 x .55526 x .04 = 3.81410
5/ Discount factor, 80.85389 x .04 = 3.23416
6/ Discount factor, 13.00649 x .04 = .52026

Increased Pasture Production
(Maximum Annual $311,700

	Annual Equivalent
A. Full annual benefit 5 years hence: $311,700 x .82193	$256,196
B. Annual cumulative benefit of $\frac{311,700}{5}$ for 5 years: $62,340 x .52026 1/	32,433
TOTAL	$288,629

Savings in Crop Production Costs
(Maximum Annual $456,100)

A. Full annual benefit 5 years hence: $456,100 x .82193	$374,882
B. Annual cumulative benefit of $\frac{456,100}{5}$ for 5 years: $91,220 x .52026 1/	47,458
TOTAL	$422,340

Additional Measures

In determining the additional measures to be recommended, each specific measure was evaluated to determine its cost and benefit, and only those with benefits in excess of costs were recommended.

The benefit-cost ratios for water retarding structures include more than one structure. However, the incremental benefit of each additional structure, in all cases, was greater than the incremental cost.

1/ Discount factor, 13.00649 x .04 = .52026

The annual equivalents of costs and benefits of the two groups of additional measures were developed as follows:

Channel Improvement

		Annual Equivalent
Costs:		
Installation:		
Federal	$623,000	$15,575
Private	189,000	7,560
Maintenance:		
Other Public	12,600	12,600
Private	7,700	7,700
Total Cost		$43,435
Benefit:		
Land Enhancement	64,200	64,200

Floodwater Retarding Structures (Jacks Run, 4 Structures)

Costs:		
Installation		
Federal	$ 99,000	$ 2,475
Other Public	2,300	58
Private	1,100	44
Maintenance:		
Other Public		1,000
Total Cost		$ 3,577
Benefit:		
Reduction of Flood Damage		5,500

Floodwater Retarding Structures (Wilson Creek, 3 Structures)

		Annual Equivalent
Costs:		
Installation:		
Federal	$59,000	$1,475
Other Public	7,700	192
Private	900	36
Maintenance:		
Other Public	800	800
Total Cost		$2,503
Benefit:		
Reduction of Flood Damage		7,300

Conversion of 1949 Prices and Costs to 1955-1965 Levels

To convert the benefits and costs calculated in terms of 1949 prices and costs to those expected to prevail during the period 1955-1965 the indices shown in table G-2 were used.

The recommended program described and evaluated in these appendixes includes woodland management measures for 600,800 acres, the area which should be treated to achieve the most effective program of runoff and waterflow retardation and soil erosion prevention. An evaluation of the progress of the going program as it is now operating and as it is affected by the lack of some form of public control of forest practices on private land indicates that this full treatment will not be fully attained during the 20-year installation period. In order to make the program consistent with these indications, the recommendations presented in the report include woodland measures for only the area on which it is estimated these measures will be maintained. The quantities of woodland measures recommended in the report were obtained by reducing those shown for private woodland in the appendixes by 55 percent. Accordingly, both the areas to be treated and the costs of private woodland treatments were reduced by this percentage. The recommended woodland measures now include management for 337,300 acres of woodland at an estimated installation cost of $797,000 to the Federal Government and $1,345,000 to local interests. The revised estimates of annual operation and maintenance costs of this measure are $22,500 to the Federal Government and $66,400 to local interests. Tree and shrub planting was also revised and is now recommended on 21,400 acres at an estimated installation cost of $298,000 to the Federal Government and $211,000 to local interests. These changes resulted in a reduction of 47 percent in the total cost of the woodland measures. The annual equivalent of all costs for woodland treatment was approximated by making a reduction of 47 percent,

The benefits derived from woodland measures were reduced in proportion to the reduction in cost of these measures. This resulted in the following changes:

1. Reduction in damage due to inundation, shown on page G-5, was reduced from $43,211 to $22,900.

2. Total woodland production benefits, shown on page G-7, were reduced from $450,138 to $238,570.

The net effect on the (1949) annual costs and benefits of the land treatment measures, as shown in table G-1, was a change in costs from $1,055,613 to $934,295, and a change in benefits from $2,179,111 to $1,947,232. Costs and benefits based on 1955-1965 prices changed respectively from $693,896 to $613,832 and $1,298,587 to $1,160,550, making a benefit-cost ratio of 1.89 to 1. The revised ratio for the entire recommended program is changed from 1.85 to 1 to 1.87 to 1.